

USAAVLABS TECHNICAL REPORT 71-9

**UH-1 AND AH-1 HELICOPTER MAIN ROTOR BLADE FAILURE
AND SCRAP RATE DATA ANALYSIS**

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January 1971

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U. S. ARMY AIR MOBILITY RESEARCH AND DEVELOPMENT LABORATORY
FORT EUSTIS, VIRGINIA**

**CONTRACT DAAJ02-70-C-0016
BELL HELICOPTER COMPANY
FORT WORTH, TEXAS**

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Preliminary studies of the impact of the Army's operational environment on helicopter rotor blade failure rates indicate that external causes (combat damage, etc.) are considerably greater than causes associated with blade design (fatigue failure, etc.). This contract was initiated to assess the impact of the Army's operational environment on the scrap and failure rate of UH-1 and AH-1 series main rotor blades. Results reported herein show that the Army is experiencing very high maintenance support costs primarily due to extremely poor repairability characteristics. The need for design concepts with a high degree of field repairability is evident. These findings suggest that a highly repairable blade concept incorporating replaceable blade segments or a relatively cheap, expendable rotor blade concept may prove fruitful. Design studies of these concepts are currently under way. This report is published to assist designers of rotor systems by providing a better understanding of the reasons for blade failure and the distribution according to operational conditions.

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ABSTRACT

This report presents the results of an investigation of the impact of the Army's operational environment on UH-1 and AH-1 series main rotor blades. Thirty-nine months of operational data for missions flown in the United States as well as in Southeast Asia under actual combat conditions were reviewed and reported. Blade failures are reported in terms of cause, frequency, repairability, and probability of blade scrappage following removal. The maintenance man-hours associated with each type of repair, the most forward area at which repairs may be accomplished, and the associated downtimes and support costs are reported. Repair, overhaul, and new blade costs are converted to operational costs in dollars per flight hour. The concepts of blades with a high degree of field repairability and "throwaway" blades are discussed. Target new blade costs at which such concepts become cost effective are developed.

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I. SUMMARY

The main rotor blade analysis was conducted and this report was prepared under Contract DAAJ02-70-C-0016. Analysis of premature removal, time change, repair and scrap data was conducted on the two types of the UH-1/AH-1 series aircraft main rotor blades shown in Table I.

TABLE I. MAIN ROTOR BLADES ANALYZED

Blade Part No.	Models Used On	Cost of* New Blade	Allowable Operating Time
204-011-250-5	UH-1D/UH-1H	\$2918.19	2500 hours
540-011-001-5	UH-1C/AH-1G	\$3151.71	1100 hours
* Contract DAAJ01-68-A-0022, Spare Parts Cost List			

The results of the analysis to determine the mean-time-to-removal (MTR) and mean-time-between-removals (MTBR) are shown in Table II. Values are expressed in blade hours.

TABLE II. MTR AND MTBF VALUES
FOR MAIN ROTOR BLADES

Blade Part No.	Reason For Removal	Combat Area		CONUS Area	
		MTR	MTBR	MTR	MTBR
204-011-250-5	All	¹ 409	⁵ 1063	³ 993	⁷ 720
	Part Causes	520	5560	994	1919
	External Causes	369	1326	766	2879
540-011-001-5	All	² 316	⁶ 908	⁴ 476	⁸ 1449
	Part Causes	371	3602	455	2974
	External Causes	272	1252	290	4036
1. Based on 4609 blade removals, TAERS Data. 2. Based on 1288 blade removals, TAERS Data. 3. Based on 333 blade removals, TAERS Data. 4. Based on 53 blade removals, TAERS Data. 5. Based on 136 removals and 144,556 blade hours, TAERS Data. 6. Based on 250 removals and 226,920 blade hours, TAERS Data. 7. Based on 16 removals and 11,516 blade hours, TAERS Data. 8. Based on 39 removals and 56,508 blade hours, M & R Data.					

The MTR/MTBR values are for blades removed during the period from 1966 through 1969. The MTR's for the combat area (Vietnam) are sensitive to combat intensity during shorter periods.

The results of the scrappage data analyses are shown in Tables III and IV.

TABLE III. REASON FOR REMOVAL VERSUS REASON FOR SCRAPPAGE* AT A BLADE REPAIR FACILITY
(As a percentage of the total number of blades that were scrapped)

Blade Part No. 204-011-250-5 (UH-1D/H)					
Reason For Scrappage	Reason For Removal				
	All Causes	Part Causes	External Causes	No Failure Causes	Unknown Causes
<u>All Causes</u>	<u>100.00%</u>	<u>20.50%</u>	<u>41.19%</u>	<u>1.76%</u>	<u>36.55%</u>
Part Causes	73.38%	17.61%	26.83%	1.48%	27.46%
External Causes	24.16%	2.68%	13.73%	0.28%	7.47%
Time Change	0.28%	0.00%	0.14%	0.00%	0.14%
Other	2.18%	0.21%	0.49%	0.00%	1.48%
Blade Part No. 540-011-001-5 (UH-1C/AH-1G)					
Reason For Scrappage	Reason For Removal				
	All Causes	Part Causes	External Causes	No Failure Causes	Unknown Causes
<u>All Causes</u>	<u>100.00%</u>	<u>15.54%</u>	<u>55.13%</u>	<u>6.16%</u>	<u>23.17%</u>
Part Causes	29.91%	8.50%	11.44%	1.17%	8.80%
External Causes	56.89%	4.69%	40.76%	0.59%	10.85%
Time Change	5.87%	1.76%	0.00%	3.52%	0.59%
Other	7.33%	0.59%	2.93%	0.88%	2.93%
* From BHC Blade Repair Facility Data					

**TABLE IV. PROBABILITY OF SCRAPPAGE
OF MAIN ROTOR BLADES
REMOVED IN VIETNAM**

Blade Part No.	Reason For Removal	Probability of Scrappage Range (90% Confidence)		
		Of Total Blades Removed	At the Removal Location	Of Blades Shipped For Repair
204-011-250-5 (UH-1D/H)	Both Causes	65.8-74.1	27.7-36.1	62.1-73.2
	Part Causes	51.1-66.9	14.7-27.6	54.1-73.7
	External Causes	70.0-79.4	31.8-42.2	62.5-75.9
540-011-001-5 (UH-1C/AH-1G)	Both Causes	71.5-79.2	49.7-58.6	64.1-78.7
	Part Causes	63.0-84.1	40.1-64.2	46.0-89.6
	External Causes	71.3-79.6	49.6-59.2	63.6-79.3

By the time the blades arrive at a blade repair facility most of the blades that were obviously not reparable were scrapped. The blades that are scrapped at the repair facility are blades with defects that can be seen only when the blades are disassembled or at least given an inspection more detailed than the previous one. The reasons for blade scrappage at a repair facility may therefore differ from the reasons for removal. Prior to the blades reaching a repair facility the reason for scrappage of a blade is usually consistent with its reason for removal. Exceptions to this are the blades that are damaged during or after removal.

The Probability of Scrappage analysis considered 331 UH-1D/H blade removals during the Julian calendar period 7200 through 7299 and 336 UH-1C/AH-1G blade removals during the period 7200 through 8099. The UH-1C/AH-1G blades show a greater probability of scrappage at the point of removal than do the UH-1D/H blades, while the scrappage probabilities of the blades shipped for repair are comparable.

The results of the analysis of main-rotor-blade support-costs is shown in Table V (based on a 5000-hour aircraft life cycle).

**TABLE V. MAIN ROTOR BLADE SUPPORT COSTS
FOR AIRCRAFT STATIONED IN
VIETNAM**

Blade Part No.	Using New Replacement Blades Only		Using Both New & Repaired Blades
	* Minimum Cost \$/Flt. Hr.	** Maximum Cost \$/Flt. Hr.	*** Estimated Cost \$/Flt. Hr.
204-011-250-5 (UH-1D/H)	\$10.73	\$12.14	\$10.02
540-011-001-5 (UH-1C/AH-1G)	15.32	18.00	14.81
<p>* Based on the replacement of all blades not reparable at point of removal with new blades</p> <p>** Based on the new blade replacement and no blade repair</p> <p>*** Based on air transport of damaged blades to CONUS and new and repaired blades to Vietnam</p>			

The existing program of blade repair even with the large percentage of scrapped blades is cost effective, about two to four dollars per flight hour less expensive than the support cost would be if no blades were repaired. It is \$0.51 to \$0.71 less expensive than the support cost would be if the blade repairs were limited to those that could be accomplished at the point of removal. If the percentage of repairs at the point of removal could be increased sufficiently, it would become cost effective to eliminate the repair programs at CONUS facilities.

II. INTRODUCTION

This report was prepared in accordance with the requirements of Contract DAAJ02-70-C-0016, UH-1 and AH-1 Helicopter Rotor Blade Failure and Scrap Rate Data Analysis.

The purpose was to conduct an analysis of UH-1 and AH-1 series helicopter main rotor blade failures and scrappage. The analysis treats the data in two major groups.

- The UH-1D/H main rotor blades
- The UH-1C/AH-1G main rotor blades

In the case of the UH-1D/H, the analysis considers only the improved version of the blades currently used. All blades used on the UH-1C/AH-1G are of improved design.

The analysis also develops the following:

- Mean-time-to-removal (MTR) and mean-time-between removals (MTBR) under combat and noncombat conditions
 - . Due to part causes
 - . Due to external causes
- Probability of scrappage for blades removed in combat areas for part and external causes
- A correlation of the reasons for removal in the field and the reason for scrappage at a blade repair facility
- Aircraft support costs in dollars per flight hour for main rotor blades

The analyses in this report provide a basis for evaluation of MTR, MTBR, reparability, and rotor blade support cost characteristics of future blade designs.

III. ANALYSIS APPROACH

A. DATA FILES

Bell Helicopter Company (BHC) has four main sources of main rotor blade failure, removal, repair, and scrap data. They are:

1. The Army Equipment Record System (TAERS) DA2410, Component Removal and Repair/Overhaul Record Data

These data are supplied on magnetic tape to BHC as Government Furnished data under the UH-1/AH-1 Maintainability and Reliability (M & R) Program, Contract DAAJ01-67-C-1588(G). Limited computer programs were developed under the M & R Program to sort, select and list the TAERS data.

2. The Field Failure/Discrepancy Report (FDR) Data

These data were reported by Reliability Field Engineers who monitored groups of UH-1C/D/H and AH-1G helicopters under provisions of the UH-1/AH-1 M & R Program. Computer programs developed under the M & R Program group, list, and sum the data by failure mode.

3. The Disassembly Inspection Summary, OSM-634 Form Data

This is a government form on which BHC reports the overhaul, repair and scrapping of overhaul and limited life components from military aircraft. Computer programs were prepared under the M & R Program to list and analyze the reason-for-removal file and the parts-replaced and assemblies-scrapped file. A small computer program was prepared under this contract to correlate the reasons-for-removal and the reasons-for-scrapping by serial number of the blades scrapped by BHC.

4. Red River Army Depot (RRAD) Main Rotor Blade Inspection Records

These data initially contained the date of inspection, the blade part number and serial number, whether the blade was scrapped, to be held for additional records, or forwarded to a repair facility, and if scrapped, the reason for scrapping. Later the records were expanded to include the total time on each blade. Copies of these records were obtained by the BHC Quality Department as informal data exchange. The data on the records were transcribed into the OSM-634 tape files for listing and analysis using the existing overhaul data computer programs.

Flight hour data were obtained from two sources:

- Monthly flight reports of the M & R Program monitored aircraft
- Form DA1352 listings of flying hour data on BHC helicopters (Reference 1)

B. COMBAT AND NONCOMBAT AIRCRAFT

The combat aircraft were those stationed in Southeast Asia. All others were considered noncombat aircraft. The two data sources from which Vietnam aircraft or organizations could be identified were the TAERS 2410 data and the FDRs. They could not be determined from the BHC and RRAD data.

1. TAERS Data

BHC has 45 magnetic tapes of DA2410 data. To facilitate the analysis, two tape files were created, one of UH-1D/H blades (P/N 204-011-250-5) and one of UH-1C/AH-1G blades (P/N 540-011-001-5). Each blade record contains a code which identifies the organization that prepared the report. Insofar as possible, the codes in the blade file were identified using the Directory and Station List of the United States Army (Reference 2). The results are shown in Table VI.

TABLE VI. ORGANIZATION CODES IDENTIFIED
IN TAERS DATA

	Blade File	
	UH-1D/ UH-1H	UH-1C/ AH-1G
Number of Army Codes In the Data File	237	164
Number Identified For Vietnam	164	120
Number Identified For CONUS	24	14
Number Not Identified	49	30

The existing computer program used to select the data (for example, the organizations coded in the removal records) was so designed that the number of different selection choices had to be limited to keep the computer time reasonable. The selection procedure limited the

choices to fifty organizations. Since less than fifty organizations other than those in Southeast Asia reported blade removals, the selection limitation did not affect the noncombat aircraft blades. However, 166 UH-1D/H and 122 UH-1C/AH-1G organizations in Southeast Asia reported blade removals, so fifty organizations in Vietnam were selected from each file. The organizations selected reported 7484 (77.5%) of the UH-1D/H and 2209 (76.4%) of the UH-1C/AH-1G blades removed in Southeast Asia which is an adequate sample.

All but fifty-six UH-1D/H and twenty-one UH-1C/AH-1G non-combat blade-removal records were from CONUS organizations so only CONUS organizations were used for the noncombat aircraft blade analysis. Two of the CONUS organizations' data were omitted because it was suspected that their blade removals were primarily from Vietnam aircraft sent back for repair. These were Red River Army Depot and the U. S. Army Aeronautical Depot Maintenance Center (ARADMAC). Their deletion reduced the number of CONUS removals by 2340 records (76%) for the UH-1D/H and 625 records (85%) for the UH-1C/AH-1G blades. From the above, four analysis files were established, two for each blade type for each of the two locations. To assure that only the improved blade removals were analyzed, all UH-1D/H blades records with serial number less than A2-2400 were eliminated.

If more time had been available, it may have been possible to salvage some of the ARADMAC removal records for the CONUS analysis. This would require identifying the serial numbers of the aircraft from which the blades were removed and with additional research determining the aircraft that were previously at a CONUS facility. Even so, it is probable that most of the reasons for removal were to facilitate maintenance.

2. FDR Data

The FDR data used in the MTBR analyses were those reports from the M & R Program field monitoring periods of:

- April 1966 through October 1967 for the UH-1C
- April 1966 through November 1967 for the FY 1965 and 1966 UH-1D/H
- July 1967 through October 1969 for the AH-1G

The CONUS and Vietnam data were analyzed separately. However, the UH-1D/H data for CONUS were inadequate

(0 removals) for the very small monitoring period (5851 flight hours) to provide any meaningful numbers.

C. REASONS FOR BLADE REMOVAL AND SCRAPPAGE

The reasons for blade removal were divided into four major classes (which are defined in Appendix A):

- Part Causes
- External Causes
- No Failure Causes
- Unknown Causes

These were further divided into subgroups as shown on Table VII. The individual removal reasons coded on TAERS data and reported in the OSM-634 files were assigned to the subgroup to which they seemed most appropriate. Reasons that did not seem to be appropriate blade failure modes or removal reasons were grouped with the "Unknown Causes." The individual removal reasons are shown in Appendix B.

The same major classes and subgroups were used to group failure modes found in the FDR data for the MTBR analyses.

The reasons for scrappage were also grouped into four major classes:

- Part Causes
- External Causes
- No Failure Causes
- Other Causes

These were further divided into subgroups as shown on Table VIII. The individual reasons for scrappage were placed in the subgroups that seemed most appropriate. The individual reasons for scrappage are shown in Appendix B.

While the BHC blade repair and scrap records contain the reason-for-removal that was reported on the DA2410 form received with the blade as well as the reason for scrappage, the RRAD records contained only the reasons for

TABLE VII. THE SUBGROUPS OF THE MAJOR REASONS FOR REMOVAL

I.	<u>PART CAUSES</u>
	A. Excessive Vibration
	B. Deterioration
	C. Bonding Failure
	D. Excessive Wear
	E. Corrosion
	F. Other
II.	<u>EXTERNAL CAUSES</u>
	A. Foreign Object Damage
	B. Overstressed
	C. Heat Damage
	D. Maintenance and Shipping Damage
	E. Other
III.	<u>NO FAILURE CAUSES</u>
	A. Time Change
	B. Other
IV.	<u>UNKNOWN CAUSES</u>

TABLE VIII. REASONS FOR SCRAPPAGE SUBGROUPS

I.	<u>PART CAUSES</u>
	A. Imbalance
	B. Deterioration
	C. Bonding Failure
	D. Corrosion
	E. Water Contamination
II.	<u>EXTERNAL CAUSES</u>
	A. Foreign Object Damage
	B. Overstressed
III.	<u>NO FAILURE CAUSES</u>
	A. Time Change
IV.	<u>OTHER CAUSES</u>
	A. Unknown

scrappage. In the past, as the RRAD data were received, assumptions were made as to the reasons for removal based on the reasons for scrappage, and these assumptions were entered into the data form when the RRAD were transcribed into OSM-634 format. Where an assumption could not be made the reason for removal was coded "Unknown." The RRAD data Reason for Removal/MTR analyses contained in Appendix F include the assumed removal reasons. However, when analyses were made to compare reasons-for-removal with reasons-for-scrappage, only the BHC data were used. Prior to the blades reaching a repair facility the reason-for-scrappage of a blade has been assumed to be the same as the reason-for-removal. (Exceptions to this assumption are the blades that are damaged during or after removal.) This assumption has been necessary because TAERS DA2410 data that BHC has received contain very few records of blade scrappage, even though there is a standard procedure for reporting scrapped serial-numbered items.

D. MEAN-TIME-TO-REMOVAL (MTR)

MTR for the main rotor blades is the sum of the times at removal for all blades divided by the number of blades removed.

$$MTR = \frac{\sum_{i=1}^{i=n} t_i}{n} \quad (1)$$

where

t_i = the total time at removal of the i th blade,
in hours

n = the number of blades removed

MTR was computed from TAERS, OSM-634 and RRAD data because these sources were the most adequate for this calculation. The blade removals that were for "no failure causes" other than "time change" were omitted from the TAERS data analysis. Since these removals were made to facilitate maintenance or to provide blades for another aircraft (cannibalization), etc., they are outside the scope of the analysis. However, these reasons were included in the OSM-634 and RRAD data since the blades received for repair that were removed for these reasons were either damaged in the removal process or after being removed, or they were shipped to be repaired for another reason (perhaps unintentionally).

The unknown (or unstated) removal reasons were analyzed as a group. This was done to see whether the MTR for this group was similar to that obtained from the part and external cause removal records. A similar MTR would indicate the probability that the distribution of the "Unknown" group is similar to the combined part and external cause groups.

E. MEAN-TIME-BETWEEN-REMOVALS (MTBR)

The MTBR for main rotor blades is twice the sum of the flight hours of the group of aircraft from which the blades were removed divided by the number of blades removed during those flight hours.

$$MTBR = \frac{2 \sum_{j=1}^{j=m} t_j}{n} \quad (2)$$

where

t_j = the total flight hours of the j th aircraft

m = the number of aircraft in the group

n = the number of blades removed

MTBR was computed from TAERS and FDR data because flight time for the aircraft were available for use with these sources.

1. MTBR From TAERS Data

To compute MTBR from TAERS data it was first necessary to select a group of aircraft for which total flight times could be established. Next the TAERS data were searched to identify every blade removal recorded against each of the aircraft. Each removal reason and blade time was recorded.

The aircraft selected were the same M & R Program monitored aircraft that were used to compute the MTBR from FDR data. This was done because these aircraft could be readily identified as to CONUS or Vietnam location. The main difference is the TAERS data cover the entire life of the aircraft through 31 December 1969.

MTR and reason-for-removal values for the total files (Vietnam and CONUS) were compared with the values calculated for the selected aircraft samples. The results (Appendix D, Table D-X) are similar for the UH-1C/AH-1G aircraft in Vietnam. There was less similarity between the values for UH-1D/H in Vietnam and very little similarity between the values for the UH-1D/H in CONUS. However, in the latter case there were only sixteen blade removals recorded in TAFRS for the ten monitored UH-1D/H's in CONUS, an inadequate sample for comparison.

No comparison could be made for the UH-1C/AH-1G CONUS because there were no CONUS removals recorded where other data did not show the aircraft also stationed in Vietnam.

2. MTBR From FDR Data

The FDR data were reviewed for the main rotor blade failures reported and those found were grouped into three sets:

- Failures that resulted in blade replacement
- Failures that resulted in blade removal for repair or replacement
- Failures that resulted in blade repair (either with blade removed or not removed) or replacement

The first set is a subset of the second which is a subset of the third as shown in Figure 1.

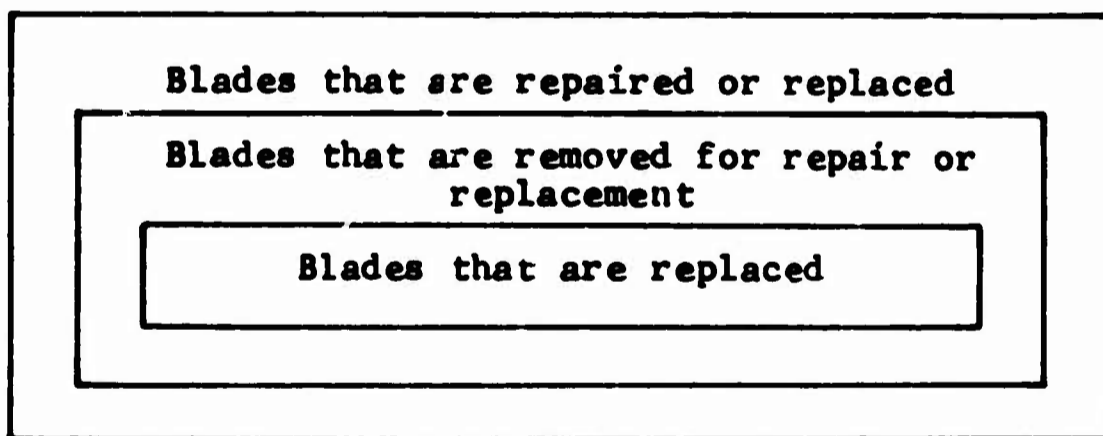


Figure 1. Set/Subset Relationship of the M/R Blade Failures Found in the FDR Data.

The results of this analysis are shown in Appendix E.

The MTBR values were computed for main rotor blade failures that resulted in the blade being removed for repair or replacement. The time base for the analysis was the sum of the flight hours for the aircraft during the monitoring period. The results are shown on Tables XII and XIII in Section IV together with the values obtained from TAERS data.

F. PROBABILITY OF SCRAPPAGE/REPAIR ANALYSES

Since the scrap probability analyses needed input from all three data sources, sample groups of data were selected from TAERS that had dates of removals for blades that would be expected to be found in the RRAD and BHC records. The data groups selected were those with Julian dates starting 72, 73, 80 and 81. Since this analysis could not be mechanized but required a serial number by serial number search through listings from each of the data files, only enough data groups were used to provide an adequate data sample. For the UH-1D/H blades, the single group of removals, Julian dates from 7200 through 7299, provided a sample of 331 blades. To obtain a comparable sample (336) of UH-1C/AH-1G blades, three date groups were required, from 7200 through 8099. After the date groups were selected, each blade serial number was researched through the TAERS data, the BHC repair/scrap records, and the RRAD scrap, forward, or hold records to determine whether the blade after removal for a part or external cause was reinstalled on another aircraft, forwarded to a repair center, scrapped, repaired, held, or again forwarded.

The results of this research were summed and percentages established. Based on the number removed and the number scrapped or repaired, a 90-percent confidence interval for the probability of scrapping or repair was computed. The confidence intervals were computed using the table and equations of Reference 3.

G. AIRCRAFT MAIN ROTOR BLADE SUPPORT COST ANALYSIS

Having already determined the percentage of blades that are removed for each cause and the percentage of the blades that are removed for part and external causes (premature removals) that are repaired by the using organization and by a blade repair facility, the blade support cost can be computed.

1. General

The aircraft main rotor blade support costs are a function of the following elements that are used in this analysis:

- The aircraft life cycle**
- The rotor blade mean-time-to-removal**
- The cost of blade removal and installation**
- The cost of the blade repair system divided among the blades repaired**
- The cost of a new blade**
- The allowable operating (fatigue) life of a new blade**
- The remaining life of a repaired blade**
- The shipping costs of new and facility-repaired blades to the user**

There are other costs involved in the aircraft blade support cost cycle that have been omitted from this analysis because they are not readily obtainable and because they are minor. Some of these costs include:

- Cost of inspection and scrapping by the using organization**
- Cost of shipment from one CONUS location to another to finally arrive at a repair facility**
- Cost of shipping containers for the blades. (These are reuseable)**
- Cost of preparing removed blades for shipment**
- Cost of inspection of blades scrapped at an inspection location (such as RRAD) in the return path to a repair facility**
- Cost of repair materials at the user's location**

The costs used have been put into three adjusted blade cost groups and the cost of shipping a repaired or new blade to the user. The three adjusted blade cost groups are:

- The cost of blades repaired by the user. This includes the cost of removal, repair and reinstallation of the blades repaired at his location.
- The cost of blades repaired by a repair facility. This includes cost of removal and installation of the repaired blade, the transportation cost of all the blades that are shipped back for repair, and the repair cost.
- The cost of a new blade is increased to include the cost of removal and installation.

The cost of the new blades originally installed on the aircraft is not included in the support cost analysis.

2. User Repaired Blade Cost

The following equation is used to compute this value.

$$C_{o_r} = (T_{r_1} + T_{r_2} + T_i) C_m \quad (3)$$

where

C_{o_r} = The dollar cost of repair of a removed blade by the using organization

T_{r_1} = The time in manhours to remove a blade assembly

T_{r_2} = The time in manhours to repair a blade at the removal area

T_i = The time in manhours to install the blade assembly

C_m = The manhour cost of organizational maintenance personnel

3. Facility Repaired Blade Cost

The cost of a facility repaired blade is computed using the following equation:

$$C_{rb} = \frac{bC_m(T_{r1} + T_i) + C_{sa}(d) + C_{ss}(1-d) + bC_{tr}}{b} \quad (4)$$

where

C_{rb} = The cost of a repair of blades shipped to CONUS for repair, dollars per blade repaired

C_{sa} = The dollar cost of shipping a blade to CONUS using air transportation

C_{ss} = The dollar cost of shipping a blade to CONUS using surface transportation

C_{tr} = The dollar cost of repairing a prematurely removed blade

b = The fraction of the blades shipped to CONUS for repair that are repaired

d = The fraction of the blades shipped to CONUS by air transportation

The remaining symbols are the same as those used for equation (3).

4. New Blade Cost

For this analysis, the new blade cost is adjusted to include the cost of removing the blade that was scrapped and installing the new one. This cost is computed using equation (5).

$$C_{nb} = C_m(T_{r1} + T_i) + C_{nb_f} \quad (5)$$

where:

C_{nb} = The adjusted cost of a new blade.

C_{nb_f} = The cost of the new blade at the factory.

5. Blade Support Cost Analysis

The blade support cost is computed using the following equation:

$$C_{bs} = \frac{\left(\frac{nL}{MTR} - n\right)}{100L} \left(C_{nb} \times g + C_{rb} \times h + C_{sa} \times e(g + h) \right. \\ \left. + C_{ss} \times f(g + h) + C_{or} \times j \right) \quad (6)$$

where

C_{bs} = Blade support cost in dollars per flight hour

L = Aircraft life cycle in flight hours

MTR = The mean-time-to-removal for repair or replacement in blade hours

g = The percentage of removed blades replaced by new blades

h = The percentage of removed blades replaced by CONUS facility repaired blades

j = The percentage of the blades removed that are repaired by the using organization

e = The fraction of the blades shipped from CONUS that are transported by air

f = The fraction of the blades shipped from CONUS by surface transportation

n = The number of blades in the rotor

For these analyses

$$g + h + j = 100 \quad (7)$$

and

$$e + f = 1 \quad (8)$$

To compute the cost of repair by the using organization, the average blade removal, repair, and installation manhours

spent by the using organization were taken from a DA2407 Maintenance Report data listing for the UH-1H and AH-1G. The results are shown in Table IX.

TABLE IX. ORGANIZATIONAL MAINTENANCE MANHOUR REQUIREMENTS AND COSTS*

Activity	UH-1H		AH-1G	
	Average Manhours	Dollars	Average Manhours	Dollars
Blade Removal (T_{r_1})	3.73	13.06	3.72	13.02
Blade Installation (T_i)	3.73	13.06	3.72	13.02
Blade Repair (T_{r_2})	6.00	21.00	6.50	22.75
TOTAL (C_{or})	13.46	47.12	13.94	48.79
* Costs are based on \$3.50 per organizational maintenance manhour. This is approximately a 30-percent increase over the \$2.67 shown in U. S. Army Field Manual 101-20 dated 15 December 1966 (Reference 4)				

Cost of main rotor blade shipment to or from Southeast Asia is (Reference 5):

- \$114.00 by air transportation
- \$82.00 by surface transportation

Cost of a new blade at Bell Helicopter Company is (Reference 6):

- \$2918.19 - UH-1D/UH-1H
- \$3151.71 - UH-1C/AH-1G

The average cost of blade repair at Bell Helicopter Company (as developed by the Cost Analysis Group) is:

- \$925.00 - UH-1D/UH-1H
- \$787.00 - UH-1C/AH-1G

The allowable operating time (AOT) for the blades is (References 7, 8, and 9):

- 2500 hours - UH-1D/UH-1H
- 1100 hours - UH-1C/AH-1G

From the earlier analyses, the MTR's of the blades removed in Vietnam and of the blades repaired at BHC, the ratio of the fatigue life remaining in the repaired blade to the blade MTR was developed as shown in Table X.

TABLE X. LIFE REMAINING IN REPAIRED BLADES

	Blades	
	UH-1D/H	UH-1C/AH-1G
MTR of blades removed in Vietnam	409 hrs	316 hrs
MTR of blades repaired at BHC	310 hrs	241 hrs
Blade AOT	2500 hrs	1100 hrs
Fatigue life remaining in BHC repaired blades	2190 hrs	859 hrs
Ratio of the fatigue life remaining to the MTR of blades removed in Vietnam	5.4:1	2.7:1

Since the ratio of the fatigue life remaining on the repaired blade to the Vietnam blade MTR is high, the analysis does not include the consideration of the reduced life of the repaired blades.

IV. ANALYSIS RESULTS

A. MTR ANALYSIS

1. Model UH-1D/UH-1H Blades

Table XI from TAERS data shows that the All Data values closely resemble the Vietnam data values. This is to be expected since the majority of the blade removal records were from aircraft stationed in Vietnam. The CONUS values are considerably higher than those from Vietnam. Also a much higher percentage of CONUS blades survive to scheduled retirement life. This reflects the difference in environment vulnerability of the blade to the two use locations. The combat environment produces blade strike and foreign object damage (FOD) (i.e., bullet damage). Also, the maintenance care given to the blades in CONUS is a rarity that must be of a lower priority in the combat zone maintenance environment.

The percentage of the blades removed for "External Causes" in Vietnam is almost three times that for "Part Causes." In CONUS, the percentage removed is less for "External Causes" than for "Part Causes." A review of the more detailed tables in Appendix D shows that the major external removal cause in Vietnam is the combination of "battle damage" and "punctured" (almost 1000 removals) which is practically nonexistent in the CONUS data (four removals).

2. Model UH-1C/AH-1G Blades

Table XII shows characteristics very similar to those of Table XI for the UH-1D/H blades. The MTR values are somewhat lower than those for the D/H blades. The percentage for "External Cause" removals in Vietnam is again almost three times the percentage of "Part Cause" removals, with "battle damage" and "punctured" again being the major external removal cause. The CONUS MTR values had to be determined from a very small number of removals. At the end of March 1970, Bell Helicopter Company helicopter operation records show that over 47 UH-1C and 79 AH-1G aircraft were assigned to CONUS organizations (not including aircraft being rebuilt at ARADMAC and the BHC Amarillo facility or recently delivered aircraft in transit). These numbers of aircraft are small when compared to the number stationed in Vietnam, and either only a few have had blade removals, or, what is more likely, all the removals are not being reported. Even so, it is significant that a comparatively large percentage of the CONUS blades is replaced for time change.

TABLE XI. REASONS FOR REMOVAL AND MEAN-TIME-TO-REMOVAL
(UH-1D/H MAIN ROTOR BLADES)

Blades From Aircraft Model(s): UH-1D/H Part No.: 20-111-250-3

REASON FOR REMOVAL	ALL DATA		VIETNAM DATA		CONUS DATA	
	MTR	PERCENT OF ALL CAUSES	MTR	PERCENT OF ALL CAUSES	MTR	PERCENT OF ALL CAUSES
<u>ALL CAUSES</u>	453.5	100.00	408.6	100.00	593.2	100.00
<u>I. PART CAUSES</u>	546.7	26.04	519.5	23.12	770.5	128.19
A. Excessive Vibration	355.1	6.34	396.5	4.06	532.2	89.71
B. Deterioration	597.3	8.49	538.6	9.14	1,110.5	187.11
C. Bonding Failure	580.8	5.80	515.5	5.16	949.3	159.91
D. Excessive Wear	657.4	3.84	594.2	3.84	1,156.1	194.86
E. Corrosion	648.9	1.57	557.5	2.00	635.3	107.08
<u>II. EXTERNAL CAUSES</u>	398.8	63.10	369.4	67.04	765.2	128.99
A. Foreign Object Damage	398.5	53.82	373.3	56.76	744.0	125.38
B. Overstressed	400.4	9.02	348.5	10.07	255.7	43.09
C. Heat Damage	349.7	0.18	333.1	1.17	-	-
D. Maintenance and Slipping Damage	106.0	0.01	-	0.00	-	-
E. Other	583.6	0.06	179.5	0.09	-	-
<u>III. NO FAILURE CAUSES</u>	1,658.8	1.06	749.5	0.35	1,234.9	208.19
A. Time Change	1,658.9	1.06	749.6	0.35	1,234.9	208.19
<u>IV. UNKNOWN CAUSES</u>	428.4	9.80	404.7	1.37	500.5	84.38
TOTAL NO. OF REMOVALS	8,222		4,609		3,339	

* Does not include Red River Army Depot and ARADMAC coded blade removals.

TABLE XII. REASONS FOR REMOVAL AND MEAN-TIME-TO-REMOVAL
(UH-1C/AH-1G MAIN ROTOR BLADES)

Blades From Aircraft Model(s): UH-1C/AH-1G
Part No.: 540-011-0C1-3

REASON FOR REMOVAL	ALL DATA		VIETNAM DATA		COMUS DATA*	
	MTR	PERCENT OF ALL CAUSES	MTR	PERCENT OF ALL CAUSES	MTR	PERCENT OF ALL CAUSES
<u>ALL CAUSES</u>	337.7	100.00	315.5	100.00	475.7	100.00
I. <u>PART CAUSES</u>	241.8	24.14	321.1	23.43	455.3	33.36
A. Excessive Vibration	258.5	7.94	324.6	6.68	509.1	15.09
B. Deterioration	393.7	6.72	410.9	6.68	544.6	9.43
C. Bonding Failure	441.6	5.35	340.3	5.43	97.0	3.77
D. Excessive Wear	412.4	2.72	418.3	3.03	371.0	3.77
E. Corrosion	427.5	1.41	412.7	1.63	462.0	1.89
II. <u>EXTERNAL CAUSES</u>	283.6	64.23	271.7	68.72	290.2	41.51
A. Foreign Object Damage	285.4	55.40	279.7	58.70	232.0	30.13
B. Overstressed	273.1	9.17	223.8	9.70	445.3	11.32
C. Heat Damage	201.0	0.27	117.7	0.23	-	0.00
D. Maintenance and Shipping Damage	488.5	0.09	488.5	0.16	-	0.00
III. <u>NO FAILURE CAUSES</u>	285.7	4.76	234.1	2.33	394.7	16.87
A. Time Change	985.7	4.76	934.1	2.33	994.7	16.87
IV. <u>UNKNOWN CAUSES</u>	288.7	6.17	265.2	5.43	229.3	5.66
TOTAL NO. OF REMOVALS	2,204		1,288			53

* Does not include Red River Army Depot and AFADWAC coded blades removals.

B. MTBR ANALYSIS

1. Model UH-1D/UH-1H Blades

Table XIII shows fairly similar results from the two data sources for the Vietnam blades. The CONUS values are questionable since the time base is so low. The main difficulty with this analysis was that aircraft had to be selected that were stationed for the majority of their life in either Vietnam or CONUS. It was fairly easy to identify aircraft for the Vietnam analysis, but there were very few CONUS aircraft that could be identified that had not spent a good portion of their operating life in Vietnam.

It is interesting to note that the Vietnam results show that the MTBR for "external cause" removals is about one-third that for "part cause." This means the removal rate for "external cause" removals is again about three times that for "part cause," which is in agreement with the results of the MTR analysis.

2. Model UH-1C/AH-1G Blades

Table XIV shows marked similarity of Vietnam MTBR values for the two data sources. It also shows the three-to-one removal rate relationship between the "external cause" and "part cause" removals.

The TAERS CONUS data records were too few to provide a meaningful analysis. The M & R CONUS analysis shows the higher mean-times that can be expected from the better use environment.

C. MAIN ROTOR BLADE SCRAP ANALYSIS

1. General

Through the UH-1/AH-1 M & R Program and other sources, it was determined that the following are the basic reasons that a blade removed from an aircraft is scrapped:

- The blade has achieved its allowable operating time.
- The blade is damaged beyond repair prior to removal.
- The blade is damaged beyond repair during or after removal.

TABLE XIII. REASONS FOR REMOVAL VERSUS MEAN-TIME-BETWEEN-REMOVALS
(UH-1D/H MAIN ROTOR BLADES)

Blades From Aircraft Model(s): UH-1D/H		Part No. 26-000-210-5			
REASON FOR REMOVAL	MEAN TIME BETWEEN REMOVALS				
	VIETNAM			TOTAL	
	YEAR DATA	TAERS DATA	YEAR DATA	TAERS DATA	
<u>ALL CAUSES</u>	<u>914</u>	<u>1,063</u>			<u>1,977</u>
<u>I. PART CAUSES</u>	<u>3,773</u>	<u>5,540</u>			<u>9,313</u>
A. Excessive Vibration	22,400	72,275			94,675
B. Deterioration	-	18,070			18,070
C. Bonding Failure	4,480	9,637			14,117
D. Excessive Wear	-	144,556			144,556
E. Corrosion	-	-			-
<u>II. EXTERNAL CAUSES</u>	<u>1,211</u>	<u>1,326</u>			<u>2,537</u>
A. Foreign Object Damage	1,948	1,417			3,365
B. Overstressed	3,200	20,651			23,851
C. Heat Damage	-	-			-
D. Maintenance and Shipping Damage	-	-			-
<u>III. NO FAILURE CAUSES</u>	<u>-</u>	<u>-</u>			<u>3,322</u>
A. Time Change	-	-			-
<u>IV. UNKNOWN CAUSES</u>	<u>-</u>	<u>144,556</u>			<u>144,556</u>
Blade time base, hours	64,800	144,556	4324		213,680

TABLE XIV. REASONS FOR REMOVAL VERSUS MEAN-TIME-BETWEEN-REMOVALS
(UH-1C/AH-1G MAIN ROTOR BLADES)

Blades From Aircraft Model(s): UH-1C/AH-1G

Part No.: 540-011-001-5

REASON FOR REMOVAL	MEAN TIME BETWEEN REMOVALS				
	VIETNAM		CONUS		
	MR DATA	TAERS DATA	MR DATA	TAERS DATA	TAERS DATA
<u>ALL CAUSES</u>	<u>930</u>	<u>908</u>	<u>1,449</u>		
<u>I. PART CAUSES</u>					
A. Excessive Vibration	<u>4,087</u>	<u>3,602</u>	<u>2,974</u>		
B. Deterioration	16,392	11,346	6,279		
C. Bonding Failure	18,733	11,943	56,508		
D. Excessive Wear	10,928	13,348	8,073		
E. Corrosion	26,226	75,640	28,254		
	-	56,730	-		
<u>II. EXTERNAL CAUSES</u>					
A. Foreign Object Damage	<u>1,203</u>	<u>1,252</u>	<u>4,036</u>		
B. Overstressed	2,017	1,609	18,836		
C. Heat Damage	6,556	5,972	5,651		
D. Maintenance and Shipping Damage	-	-	-		
E. Other	5,961	113,640	56,508		
	65,566	-	-		
<u>III. NO FAILURE CAUSES</u>					
A. Time Change	-	<u>56,730</u>	<u>14,127</u>		
	-	56,730	14,127		
<u>IV. UNKNOWN CAUSES</u>					
	-	<u>113,460</u>	<u>28,254</u>		
Blade time base, hours	131,132	226,920	56,508		

The data are inadequate to compute these values

The data are inadequate to compute these values

- The blade, reparable when removed, is improperly handled and packaged after removal and deteriorates beyond repair.
- The blade, thought reparable when removed, is later found to be either too badly damaged or too badly deteriorated to repair.
- The blade has too little fatigue life remaining to make facility repair economical.
- The time records for the blade are lost, and its appearance indicates that it might be dangerous to repair it and assign a time value.

Because most of the blades that were scrapped were not identified in TAERS, it was necessary to make certain assumptions concerning the TAERS data records that show that a blade was removed for part or external causes. They are:

- If there are records that show that the blade was later either installed on or removed from an aircraft, then the blade had been repaired after its original removal.
- If there are codes in the records that show that the blade was shipped to a repair facility, then it is assumed that the blade was shipped after removal and was not repaired by the organization that did the removal.
- If there are no records from any source on the blade after removal then it is assumed that it was scrapped by the organization that did the removal.

The Red River Army Depot (RRAD) was a receiving point for main rotor blades returning to CONUS for repair. Until recently, RRAD inspected the incoming blades and scrapped those that were not economically reparable, based on their inspection criteria. The remainder were either forwarded to a repair facility or held pending the receipt of adequate records. Since RRAD's inspection of the blades was limited to what could be seen without disassembly, most of their reasons for scrapping were for external causes. The initial RRAD data were obtained in

September 1967. Later in 1968, the total time on the blades was also included in the data. The RRAD log sheets were received until 26 May 1969, about the same time as the end of BHC's then-current blade-repair contract.

The scrap probability analyses needed input from all three data sources. Sample groups of TAERS data were selected that had dates of removal for blades that would be expected to be found in the RRAD and BHC records. The data selected were those with Julian dates starting 72, 73, 80 and 81. A review of these data showed that the number of CONUS part and external cause removals was too small and was therefore inadequate to obtain meaningful analysis values. For this reason, the probability analyses were conducted using only Vietnam blade removal records.

2. Probability of Scrappage and Repair

Tables XV, XVI, XVII, and XVIII, which summarize the results of the probability of scrappage and probability of repair analysis, show a somewhat different ratio of externally caused removals to part caused removals from that seen in the previous tables. Instead of the three-to-one ratio, the ratio is a little over two to one for the UH-1D/H blades and a little over six and one-half to one for the UH-1C/AH-1G blades. This indicates that the blade removal distributions for the periods used in the scrappage analysis were not typical of the total Vietnam blade removal distributions. This shows the need for further study. For example, the "external cause" to "part cause" removal ratio may increase considerably when other time periods of data are analyzed. This increase could relate to periods of intense battle activity such as the TET offensive in January - February 1968, when inspection criteria, the rate of field repairs, and the percentage of blades scrapped by the removing organization was extremely different from the average or normal situation.

Although the percent scrapped is similar for the two blades for combined causes, the percentages differ considerably between the two-blade types for some of the subclasses of removal reasons. For example, over 90 percent of the D/H blades removed as "overstressed" were scrapped, while only 59 percent of the C/G blades removed for the same reason were scrapped. Conversely, over 94 percent of the C/G blades removed for "deterioration" were scrapped, while only 56 percent of the D/H blades removed for this reason were scrapped. Although this variance was not explained by the analyses conducted, it is probably partially

TABLE XV. PROBABILITY OF SCRAPPAGE OF UH-1D/H
MAIN ROTOR BLADES REMOVED IN VIETNAM

Part No. 20-011-250-5

Blades From Aircraft Model(s): UH-1D/H

Reason for Removal	Removing Organization				Inspection/Repair Facility				Total	
	Total Removed	No. Scrapped	% Scrapped of Total Removed	Scrap Probability (90% Confidence Interval)	Total Shipped	No. Scrapped	% Scrapped of Total Shipped	Scrap Probability (90% Confidence Interval)	No. Scrapped	% Scrapped of Total Removed
COMBINED CAUSES*	331	105	31.7	27.7 - 35.1	197	127	64.2	62.1 - 75.2	232	70.1
I. PART CAUSES	102	21	20.4	14.7 - 27.6	62	40	64.5	34.5 - 90.2	61	59.8
A. Excessive Vibration	17	4	23.5	9.5 - 46.1	9	6	66.7	34.5 - 90.2	10	58.8
B. Deterioration	32	7	21.9	12.3 - 35.8	21	11	52.4	32.2 - 71.4	18	56.2
C. Bonding Failure	32	6	18.7	10.0 - 32.4	24	16	66.7	47.9 - 82.2	22	68.7
D. Excessive Wear	17	3	17.6	5.0 - 39.0	9	-	97.5	51.9 - 99.4	10	58.8
E. Corrosion	5	1	20.0	1.0 - 65.7	0	-	-	-	1	20.0
II. EXTERNAL CAUSES	228	84	36.8	31.8 - 42.2	125	97	77.6	55.5 - 91.2	181	79.4
A. Foreign Object Damage	206	76	36.9	31.6 - 42.6	111	75	67.6	54.9 - 84.4	152	73.8
B. Overstressed	22	8	36.4	19.6 - 56.1	14	12	85.7	61.5 - 97.4	20	90.9

*Part Causes and External Causes Only

TABLE XVI. PROBABILITY OF SCRAPPAGE OF UH-1C/AH-1G
MAIN ROTOR BLADES REMOVED IN VIETNAM

Part No. 540-011-001-5

Blades From Aircraft Model(s): UH-1C/AH-1G									
Reason for Removal	Removing Organization			Inspection/Repair Facility			Total		
	Total Removed	No. Scrapped	% Scrapped of Total Removed	Scrap Probability (90% Confidence Interval)	Total Shipped	No. Scrapped	% Scrapped of Total Shipped	Scrap Probability (90% Confidence Interval)	No. Scrapped
COMBINED CAUSES*	336	182	54.2	49.7 - 58.6	100	72	72.0	64.2 - 79.7	254
I. PART CAUSES	44	23	52.3	40.1 - 64.2	14	10	71.4	46.0 - 89.6	33
A. Excessive Vibration	11	5	45.5	20.0 - 72.9	3	1	33.3	1.7 - 86.5	6
B. Deterioration	18	13	72.2	50.2 - 88.4	5	4	80.0	34.3 - 99.0	17
C. Bonding Failure	7	4	57.1	22.5 - 87.1	2	2	100.0	22.4 - 100.0	6
D. Excessive Wear	7	0	0.0	0.0 - 28.0	4	3	75.0	24.9 - 98.7	3
E. Corrosion	1	1	100.0	10.0 - 100.0	0	-	-	-	1
II. EXTERNAL CAUSES	292	159	54.4	49.6 - 59.2	96	62	72.1	63.6 - 79.3	221
A. Foreign Object Damage	270	147	54.4	49.4 - 59.4	80	61	76.2	67.6 - 83.1	208
B. Overstressed	22	12	54.5	35.3 - 72.9	6	1	16.7	0.9 - 58.2	13

*Part and External Causes Only

TABLE XVII. PROBABILITY OF REPAIR OF UH-1D/H
MAIN ROTOR BLADES REMOVED IN VIETNAM

Blades From Aircraft Model(s): UH-1D/H

Part No. 204-011-250-5

Reason for Removal	Removing Organization				Repair Facility				Total	
	Total Removed	No. Repaired	% Repaired of Total Removed	Repair Probability (90% Confidence Interval)	Total Shipped	No. Repaired	% Repaired of Total Shipped	Repair Probability (90% Confidence Interval)	No. Repaired	% Repaired of Total Removed
COMBINED CAUSES*	221	22	11.8	9.2 - 15.0	187	55	34.1	19.3 - 39.6	55	25.4
I. PART CAUSES	103	20	19.4	13.8 - 26.6	62	14	22.6	15.1 - 32.4	34	33.0
A. Excessive Vibration	17	4	23.5	8.5 - 46.1	9	3	33.3	9.6 - 65.5	7	41.2
B. Deterioration	32	4	12.5	5.7 - 25.1	21	5	23.8	9.9 - 43.7	9	28.1
C. Bonding Failure	32	2	6.3	2.1 - 17.2	24	5	20.8	9.6 - 38.0	7	21.9
D. Excessive Wear	17	6	35.3	16.6 - 58.0	9	1	12.5	0.6 - 47.1	7	41.2
E. Corrosion	5	4	80.0	34.3 - 99.0	0	-	-	-	4	80.0
II. EXTERNAL CAUSES	228	19	8.3	5.8 - 11.9	125	31	24.8	19.0 - 31.6	50	21.9
A. Foreign Object Damage	206	19	9.2	6.4 - 13.1	111	30	27.0	20.7 - 34.4	49	23.8
B. Overstressed	22	0	0.0	0.0 - 9.9	14	1	7.1	0.4 - 29.7	1	4.5

*Part and External Causes Only

TABLE XVIII. PROBABILITY OF REPAIR OF UH-1C/AH-1G
MAIN ROTOR BLADES REMOVED IN VIETNAM

Blades From Aircraft Model(s): UH-1C/AH-1G

Part No. 300-011-001-5

Reason for Removal	Removing Organization			Repair Facility			Total	
	Total Removed	No. Repaired	% Repaired of Total Removed	Repair Probability (90% Confidence Interval)	Total Shipped	No. Repaired Shipped	% Repaired of Total Shipped	Repair Probability (90% Confidence Interval)
COMBINED CAUSES*	116	54	16.1	12.0 - 19.6	160	23.0	22.9	15.6 - 30.4
I. PART CAUSES	44	7	15.2	5.9 - 26.2	14	21.4	22.7	1.1 - 34.5
A. Excessive Vibration	11	3	27.3	7.9 - 56.4	3	66.7	45.5	20.0 - 72.9
B. Deterioration	18	0	0.0	0.0 - 12.0	3	0.0	0.0	0.0 - 12.0
C. Bonding Failure	7	1	14.3	0.7 - 52.1	2	0.0	14.3	0.0 - 52.1
D. Excessive Wear	7	3	42.9	12.9 - 77.5	4	25.0	57.1	22.5 - 97.1
E. Corrosion	1	0	0.0	0.0 - 90.0	0	-	0.0	0.0 - 90.0
II. EXTERNAL CAUSES	292	47	16.1	12.4 - 19.9	86	23.1	22.9	12.0 - 31.5
A. Foreign Object Damage	270	43	15.9	12.6 - 19.9	80	15.8	21.5	1.7 - 35.9
B. Overstressed	22	4	18.2	6.5 - 36.9	6	43.3	40.0	31.1 - 60.5

*Part and External Causes Only

related to the conditions that prevailed during the periods for which data were analyzed. With additional time, more data periods could be examined to determine if the variance is consistent. (Note that the large percentage (72%) of the C/G blades removed for "deterioration" were scrapped by the removing organization and that the period analyzed included the TET offensive of January-February 1968.) This variance precludes the establishment of special criteria for certain type removals; i.e., it would be in error to direct the scrapping of blades at the point of removal for overstress or deterioration.

It is interesting that while the removing organization scraps a higher percentage of the C/G blades (54.2%) than of the D/H blades (31.7%), it also repairs (or reuses) a higher percentage of the C/G blades (16.1%) than of the D/H blades (11.8%). Thus it naturally follows that a higher percentage of the D/H blades are shipped to CONUS for repair (56.6% versus 29.8% for the C/G blades). However, since about the same percentage of the blades shipped of each type are scrapped, this means that a higher percentage of the D/H blades that were removed are being scrapped after shipment to CONUS (38.4% versus 21.4% for the C/G blades). This suggests that better inspection criteria should be used by the organization removing the UH-1D/H blades in order to reduce the number of blades shipped to a repair facility that should have been scrapped. However, since the UH-1D/H data analyzed was only for a 100-day period in 1967, it may not be typical of later removal periods. Unfortunately, the authorized time remaining for this study when this characteristic was observed did not permit it to be investigated.

The percent scrapped plus the percent repaired do not add to 100 percent. This is because the final disposition could not be assumed for the blades held at RRAD for additional records or for the blades forwarded from RRAD to a repair facility from which there are no further data.

3. Reason for Removal Analysis of BHC and RRAD Blade Data

Tables XIX and XX show that although about the same percentage of D/H and C/G blades are scrapped, the percentage differs considerably for blades removed for part and external causes (and their subcauses). A lower percentage of C/G blades removed for part causes are scrapped than for the D/H blades similarly removed (45% versus 65.3%). Conversely, a higher percentage of the C/G blades removed

TABLE XIX. REASON FOR REMOVAL AND MEAN-TIME-TO-REMOVAL OF BLADES PROCESSED AT BHC AND RAD (UH-1D/H)**

Blades From Aircraft Model(s): UH-1D/H

Form No. 1 20-6-226-1

REASON FOR REMOVAL	BLADES PROCESSED*		BLADES REPAIRED		BLADES SCRAPPED		PERCENT OF BLADES PROCESSED THAT WERE SCRAPPED BY CAUSE
	MTR	PERCENT OF BLADES PROCESSED	MTR	PERCENT OF BLADES PROCESSED	MTR	PERCENT OF BLADES PROCESSED	
ALL CAUSES	429.3	100.0	310.0	33.1	119.7	28.1	25.7
I. PART CAUSES	450.8	16.5	308.5	5.7	146.2	32.5	32.3
A. Excessive Vibration	340.4	3.7	277.1	1.7	122.9	2.8	28.4
B. Deterioration	449.7	3.6	274.9	1.2	133.3	1.4	29.4
C. Bonding Failure	457.2	5.5	318.1	1.5	127.4	1.7	27.8
D. Excessive Wear	537.6	2.8	387.0	0.7	108.8	1.3	25.3
E. Corrosion	709.0	0.7	395.7	0.1	76.7	0.8	24.4
F. Other	258.0	0.2	213.0	0.04	269.2	0.1	21.2
II. EXTERNAL CAUSES	364.9	47.0	265.6	15.0	111.8	32.8	28.8
A. Foreign Object Damage	372.3	32.2	272.3	10.0	117.6	22.2	28.1
B. Overstressed	345.1	13.8	246.6	4.6	134.9	4.2	28.9
C. Heat Damage	494.0	0.2	518.0	0.2	170.0	0.1	20.2
D. Maintenance and Shipping Damage	179.5	0.8	277.5	0.3	116.4	0.3	21.1
III. NO FAILURE CAUSES	905.7	1.4	421.4	0.3	317.3	1.1	1.1
A. Time Change	2,064.6	0.3	-	-	2,064.6	0.3	1.0
B. Other	491.0	1.1	421.4	0.3	516.2	0.9	1.1
IV. UNKNOWN CAUSES	487.3	35.2	303.0	12.1	182.1	23.1	15.1

* Blades processed equals blades repaired at BHC plus those scrapped at BHC and at Red River Army Depot.

** Records with part time only

TABLE XX. REASON FOR REMOVAL AND MEAN-TIME-TO-REMOVAL OF BLADES PROCESSED AT BHC AND RRAD (UH-1C/AH-1G)**

Blades From Aircraft Model(s): UH-1C/AH-1G Part No.: 1-0-011-001-5

REASON FOR REMOVAL	BLADES PROCESSED*		BLADES REPAIRED		BLADES SCRAPPED		PERCENT OF BLADES PROCESSED THAT WERE SCRAPPED - BY CAUSE
	MTR	PERCENT OF BLADES PROCESSED	MTR	PERCENT OF BLADES PROCESSED	MTR	PERCENT OF BLADES PROCESSED	
ALL CAUSES	<u>341.5</u>	<u>100.0</u>	<u>242.4</u>	<u>32.1</u>	<u>355.7</u>	<u>67.3</u>	<u>67.3</u>
I. PART CAUSES							
A. Excessive Vibration	349.7	14.6	241.7	5.0	490.7	6.6	45.2
B. Deterioration	323.4	8.0	240.6	5.0	495.9	2.6	32.4
C. Bonding Failure	321.2	3.0	195.9	1.5	446.4	1.5	50.0
D. Excessive Wear	351.9	2.3	209.6	0.5	423.0	1.5	66.7
E. Corrosion	647.2	0.6	545.3	0.3	746.0	0.3	50.0
	502.0	0.7	-		502.0	0.7	100.0
II. EXTERNAL CAUSES							
A. Foreign Object Damage	286.6	55.3	235.6	13.3	302.7	1.5	76.0
B. Overstressed	292.3	45.6	251.5	7.0	300.0	1.0	90.0
C. Heat Damage	268.5	9.0	230.5	5.5	329.2	1.5	34.6
D. Maintenance and Shipping Damage	-		-		-		
	106.2	0.5	29.0	0.0	415.0	0.0	20.0
III. NO FAILURE CAUSES							
A. Time Change	811.6	6.2	306.6	1.2	919.0	5.1	82.5
B. Other	973.0	4.4	-		973.0	0.0	100.0
	397.9	1.9	306.6	1.2	550.2	0.7	57.5
IV. UNKNOWN CAUSES	<u>342.3</u>	<u>23.9</u>	<u>242.0</u>	<u>9.7</u>	<u>411.2</u>	<u>10.2</u>	<u>54.3</u>

* Blades Processed equals blades repaired at BHC plus those scrapped at BHC and at Red River Army Depot.

** Records with part time only

for external causes are scrapped than for the D/H blades similarly removed (76.0% versus 68.0%). The tables show that the MIR for the scrapped blades is considerably higher than that for the repaired blades (176.9 hours higher for the D/H blades and 147.3 hours higher for the C/G blades).

4. Reason for Scrappage Analysis of BHC and RRAD Blade Data

Tables XXI and XXII which compare the scrappage at RRAD and at BHC show that a much larger percentage of the C/G blades were scrapped at RRAD than were scrapped at BHC, while almost the same percentage of the D/H blades were scrapped at the two locations. In both blade groups between 80 and 90 percent of the blades scrapped at RRAD were scrapped for external causes.

5. Reason for Removal Versus Reason for Scrappage Analysis

From the previous analyses it was apparent that by the time the blades arrived at the repair facility most of the blades that were obviously unreparable were scrapped. The blades that are scrapped at the repair facility are blades with defects that are only discernable when disassembled or at least given a more detailed inspection than that normally achievable at the previous inspections. Therefore, in Table XXIII, it is not surprising that the majority of the reasons for the D/H blade scrappage at the repair facility (in this instance, BHC) are grouped under the part cause classification. It is surprising that in Table XXIV the same is not true for the C/G blades. Over three times as many D/H blades were scrapped at BHC for part cause than for external causes, while for the C/G blades the opposite was true at a ratio of 1.9 to one. The big factor in D/H blade scrappage was water contamination (44% of the blades scrapped), while for the same cause only a comparatively small percentage (6%) of the C/G blades were scrapped. This was so even though both were of the improved blade design. This implies that adding the improvements to the existing blade design (D/H) is not as effective as incorporating them in the original design as was done for the UH-1C/AH-1G blade.

D. AIRCRAFT MAIN ROTOR BLADE SUPPORT COST ANALYSIS

1. Blade Costs

The results of the adjusted blade cost computations are shown in Table XXV.

**TABLE XXI. SUMMARY OF REASONS FOR SCRAPPAGE
OF UH-1D/H MAIN ROTOR BLADES
SCRAPPED BY BHC AND RRAD**

Model UH-1D/H

Dwg /Part No. 204-011-250-005

REASON FOR SCRAPPAGE	Percent of Total Scrapped		
	RRAD	BHC	TOTAL
<u>ALL CAUSES</u>	<u>50.57</u>	<u>49.43</u>	<u>100.00</u>
I. <u>PART CAUSES</u>	<u>7.24</u>	<u>36.27</u>	<u>43.51</u>
A. Imbalance	0.00	.45	.45
B. Deterioration	0.07	1.22	1.29
C. Bonding Failure	0.52	2.82	3.34
D. Corrosion	6.65	9.99	16.64
E. Water Contamination	0.00	21.79	21.79
II. <u>EXTERNAL CAUSES</u>	<u>42.71</u>	<u>11.94</u>	<u>54.65</u>
A. Foreign Object Damage	33.38	7.07	40.45
B. Overstressed	9.33	4.87	14.20
III. <u>NO FAILURE CAUSES</u>	<u>0.38</u>	<u>0.14</u>	<u>0.52</u>
A. Time Change	0.38	0.14	0.52
IV. <u>OTHER CAUSES</u>	<u>0.24</u>	<u>1.08</u>	<u>1.32</u>
A. Unknown	0.24	1.08	1.32
 No. of blades scrapped	 1453	 1420	 2873

TABLE XXII. SUMMARY OF REASONS FOR SCRAPPAGE
OF UH-1C/AH-1C MAIN ROTOR BLADES
SCRAPPED BY BHC AND RRAD

Model: UH-1C/AH-1C

Dwg /Part No. 540-011-001-005

REASON FOR SCRAPPAGE	Percent of Total Scrapped		
	RRAD	BHC	TOTAL
<u>ALL CAUSES</u>	<u>65.03</u>	<u>34.97</u>	<u>100.00</u>
I. <u>PART CAUSES</u>	<u>1.85</u>	<u>10.46</u>	<u>12.31</u>
A. Imbalance	0.00	0.31	0.31
B. Deterioration	0.00	2.26	2.26
C. Bonding Failure	0.62	0.62	1.23
D. Corrosion	1.23	5.13	6.36
E. Water Contamination	0.00	2.15	2.15
II. <u>EXTERNAL CAUSES</u>	<u>57.44</u>	<u>19.90</u>	<u>77.33</u>
A. Foreign Object Damage	54.97	16.10	71.08
B. Overstressed	2.46	3.79	6.26
III. <u>NO FAILURE CAUSES</u>	<u>5.44</u>	<u>2.05</u>	<u>7.49</u>
A. Time Change	5.44	2.05	7.49
IV. <u>OTHER CAUSES</u>	<u>0.31</u>	<u>2.56</u>	<u>2.87</u>
A. Unknown	0.31	2.56	2.87
No. of blades scrapped	634	341	975

TABLE XXIII. SUMMARY OF REASONS FOR REMOVAL VERSUS REASONS FOR SCRAPPAGE OF UH-LD/H BLADES SCRAPPED AT BHC

Blades from Aircraft Model(s): UH-LD/H Part No.: 20m-11-25G-5

REASON FOR REMOVAL	REASON FOR SCRAPPAGE											
	I. PART CAUSES						II. EXTERNAL CAUSES					
	A. Imbalance	B. Deterioration	C. Bonding Failure	D. Corrosion	E. Water Contamination	F. Foreign Object Damage	A. Imbalance	B. Deterioration	C. Bonding Failure	D. Corrosion	E. Water Contamination	F. Foreign Object Damage
ALL CAUSES	1042	13	35	81	287	626	343	203	140	2	3	3
I. PART CAUSES	291	250	2	7	18	92	35	22	16	0	0	0
A. Excessive Vibration	57	50	2	2	3	10	7	4	3	0	0	0
B. Deterioration	68	53	3	3	3	25	14	6	6	0	0	0
C. Bonding Failure	100	92	1	8	33	50	7	3	4	0	0	0
D. Excessive Wear	50	40	1	4	15	20	10	7	3	0	0	0
E. Corrosion	12	11	-	-	5	3	0	-	-	0	0	0
F. Other	4	4	-	-	1	3	-	-	-	0	0	0
II. EXTERNAL CAUSES	585	391	12	38	98	250	195	129	67	2	0	0
A. Foreign Object Damage	442	277	11	35	57	172	161	114	47	1	0	0
B. Overstressed	126	91	-	3	27	60	30	11	19	0	0	0
C. Heat Damage	2	2	-	-	-	2	0	-	-	0	0	0
D. Maintenance and Shipping Damage	15	11	1	-	4	6	4	3	1	0	0	0
E. Other	0	0	-	-	-	-	0	-	-	0	0	0
III. NO FAILURE CAUSES	25	21	-	1	7	13	4	2	2	0	0	0
A. Time Change	2	1	-	-	-	1	1	1	-	0	0	0
B. Other	23	20	-	1	7	12	3	1	2	0	0	0
IV. UNKNOWN CAUSES	519	390	8	24	100	242	106	51	55	2	2	2

TABLE XXIV. SUMMARY OF REASONS FOR REMOVAL VERSUS REASONS FOR SCRAPPAGE OF UH-1C/AH-1G BLADES SCRAPPED AT BHC

Blades from Aircraft Model(s): UH-1C/UH-1G		Part No.: 540-01-001-5												
REASON FOR REMOVAL	REASON FOR SCRAPPAGE	REASON FOR SCRAPPAGE												
		I. PART CAUSES						II. EXTERNAL CAUSES						
	ALL CAUSES	I. PART CAUSES						II. EXTERNAL CAUSES						
		A. Imbalance	B. Deterioration	C. Bonding Failure	D. Corrosion	E. Water Contamination	F. Foreign Object Damage	G. Overstressed	H. Time Change	I. Other				
	341	102	22	5	20	24	129	120	120	120	120	120	120	120
I. PART CAUSES	53	29	9	1	10	14	14	14	14	14	14	14	14	14
A. Excessive Vibration	23	16	1	1	1	1	1	1	1	1	1	1	1	1
B. Deterioration	15	6	5	1	1	1	1	1	1	1	1	1	1	1
C. Bonding Failure	11	5	1	1	3	1	1	1	1	1	1	1	1	1
D. Excessive Wear	0	0	1	1	1	1	1	1	1	1	1	1	1	1
E. Corrosion	4	2	1	1	1	1	1	1	1	1	1	1	1	1
F. Other	0	0	1	1	1	1	1	1	1	1	1	1	1	1
II. EXTERNAL CAUSES	188	39	10	1	19	1	139	120	120	120	120	120	120	120
A. Foreign Object Damage	170	32	5	1	17	6	129	115	115	115	115	115	115	115
B. Overstressed	17	7	2	1	2	1	9	4	4	4	4	4	4	4
C. Heat Damage	0	0	1	1	1	1	0	1	1	1	1	1	1	1
D. Maintenance & Shipping Damage	1	0	1	1	1	1	1	1	1	1	1	1	1	1
E. Other	0	0	1	1	1	1	0	1	1	1	1	1	1	1
III. NO FAILURE CAUSES	21	4	1	1	1	1	2	1	1	1	1	1	1	1
A. Time Change	18	1	1	1	1	1	1	1	1	1	1	1	1	1
B. Other	3	3	1	1	2	1	0	1	1	1	1	1	1	1
IV. UNKNOWN CAUSES	79	30	2	4	15	9	37	38	38	38	38	38	38	38

TABLE XXV. THE COST OF BLADES TO
REPLACE THOSE REMOVED

Type of Blades	204-011-250-5 (UH-1D/H)		540-011-001-5 (UH-1C/AH-1G)	
	Basic	Adjusted	Basic	Adjusted
Blades repaired by the user at the point of removal		\$ 47.12		\$ 48.79
Blades repaired in CONUS returned from S.E. Asia by:			\$ 787.00	
- Air Transport		\$1424.09		\$1308.69
- Surface Transport		\$1291.31		\$1169.56
New Blades	\$2918.19	\$2944.25	\$3151.71	\$3177.75

The cost of a blade repaired at a repair facility is less than half of the cost of a new blade even when the repaired blade cost includes the apportioned shipping cost of the blades that were scrapped in CONUS.

The cost of a blade repaired at the point of removal is inexpensive compared to the facility repair, but the effectiveness of the field repair was not evaluated. (This would be difficult to determine.)

2. Aircraft Main Rotor Blade Support Costs

Table XXVI lists the aircraft blade support costs considering the different methods of transporting the blades, a 5000-hour aircraft life cycle and different blade replacement procedures. There is very little difference in support cost (18 to 20 cents per flight hour) between the methods of transportation used to ship blades for repair and to send new and repaired blades back to the user. (However, this would amount to \$180,000 to \$200,000 for a fleet flying a million flight hours under continued combat conditions.

If the CONUS repair procedure was stopped it would increase the support cost 89 cents per flight hour for the UH-1D/H and 56 cents per flight hour for the UH-1C/AH-1G.

With a low MTR relative to the AOT such as exists in a combat environment, a blade repair program is cost effective even when the scrap rate is high.

If the number of blades scrapped could be reduced or if the blades that are scrapped were scrapped at the point of removal, then the adjusted cost of the repaired blades could approach the basic costs shown on Table XXV.

TABLE XXVI. SOUTHEAST ASIA AIRCRAFT MAIN
ROTOR BLADE SUPPORT COSTS

Support Premise	Dollars Per Flight Hour*	
	UH-1D/UH-1H	UH-1C/AH-1G
1. Predicted cost based on the present repair/ replacement procedure - Air Transport both ways	\$10.02	\$14.81
2. Predicted cost based on the present repair/ replacement procedure - Surface Transport to CONUS and Air Transport to S.E. Asia	9.95	14.76
3. Predicted cost based on the present repair/ replacement procedure - Surface Transport both ways	9.84	14.61
4. Ideal cost - Blades removed at AOT and Surface Transport of new blades to S.E. Asia	1.21	4.62
5. No blade repair - new blades transported by Surface Transport	12.14	18.00
6. Blade repair at Organizational level only -	10.73	15.32

* For a 5000-hour aircraft life

V. CONCLUSIONS

A. MTR AND MTBR ANALYSES

The MTR analysis shows that for both UH-1D/H and UH-1C/AH-1G blades, the Vietnam combat and maintenance environment results in premature removals long before the allowable operating time is reached. On the average, the MTR is about 18 percent of the scheduled retirement life for the UH-1D/H blades and just over 30 percent for the UH-1C/AH-1G blades. A significantly longer life before removal is obtained when the aircraft is in a noncombat environment. Here a much larger percentage reach scheduled retirement and even more would if the aircraft did not have to contend with the training environment.

The blade MTR is a more understandable value than is the MTBR for use in comparing the reason-for-removal subgroups. Of course, it is necessary to have enough values to make the mean meaningful. The problem with MTBR values is that when the major reason-for-removal classes are divided into subgroups, the MTBR values increase (because fewer removals are divided into the same time base) and are difficult to evaluate.

Even though the blades have been improved as a result of field experience, the percentage of "part cause" removals (26.0% for the UH-1D/H and 24.1% for the UH-1C/AH-1G blades) indicates that further blade research is justified. The fact that the "part cause" MTR's for CONUS blades is 92 percent greater for the UH-1D/H and 23 percent greater on the UH-1C/AH-1G than for Vietnam "part cause" removals indicates that inadequate care and maintenance of the blades as well as the difference in natural environment may be important factors in the earlier removals of the Vietnam blades. This suggests that the design life of future blades should be free of preventive maintenance requirements, and the blade should be more resistant to the presently destructive elements.

B. SCRAP ANALYSIS

The probability of scrapping a blade removed for part or external causes is high. However, there does not seem to be a blade removal cause that consistently has a very low or zero repair history. More than 10 percent of the blades removed for part or external causes are repaired at the point of removal and are reinstalled on the aircraft from which they were removed, or are installed on other aircraft in the area.

requirement for major repair. But to be cost effective, the blade support cost would have to be less than the present cost. The blade cost targets (including the apportionment of engineering, tooling and test costs) are shown in Table XXVII. The method used to compute the cost targets is presented in Appendix C.

TABLE XXVII. COST TARGETS FOR
THROWAWAY BLADES*

	UH-1D/H	UH-1C/AH-1G
Present support cost using ground transportation	\$9.84/flt. hr.	\$14.61/flt. hr.
Present Vietnam MTR	408.8 hrs.	315.5 hrs.
Percent of blades repaired at point of removal	11.8%	16.1%
Cost target of a blade capable of limited repairs at the point of removal (ground transportation and same MTR)	2360.85	2814.92
Cost target of a blade that is completely nonreparable (ground transportation and same MTR)	2082.27	2351.91
* 5000-hour life cycle aircraft		

D. GENERAL

As is often the case, as a study is completed, a review of the analyses that were performed and the information that was obtained suggest areas that should be studied in more detail or over a broader scale. Such is the case with this study.

After this analysis was completed, several characteristics were noted that showed the need for additional study.

The results are very sensitive to the combat activities that occurred during the data period. For example, the TET offensive in January-February 1968 had a serious impact on the number of blades removed and the ratio of external to part cause removals.

By the time a group of blades gets to a repair facility, the reasons for scrapping of those that are scrapped do not necessarily correspond with the reasons for removal. Somewhere in the use-removal-return process the internal elements of most of the blades scrapped acquire water contamination, which will cause or may already have caused bond deterioration and corrosion.

C. AIRCRAFT MAIN ROTOR BLADE SUPPORT COSTS

The support costs would decrease if more of the blade repairs were accomplished in the field and if more of the blades that are scrapped were repaired. For this reason there has been concern about the number of blades scrapped and the desire for a more reparable blade for the UH-1/AH-1 series aircraft. To date, no in-depth study has been made to determine the reparability of the existing blades. The present criteria for blade damage inspection and reparability have been based on conservative estimates as to the diminished fatigue life produced by the damage (and wear) observed and the resulting repair, and the estimated cost of repair. A study should be made to determine blade reparability that includes the testing of blades already damaged. A second study should be made to evaluate blade repair cost (including the cost of the parts replaced) versus the allowable fatigue life remaining. This study should produce a repair cost formula that considers the remaining fatigue life. For example, it could be cost effective to perform an expensive repair on a low-time blade while a higher time blade requiring the same repair would be scrapped. These studies would be well worth their cost considering the millions of dollars expended for new blades. For a new blade designed for high reparability, the question that is unanswered is what the basic cost of such a blade would be. It could be quite expensive since such a blade would have to have redundant load members, removable panels, etc.

An alternative approach would be a less expensive blade with little or no capability for field repair and no

- The analysis of scrappage and repair of the UH-1D/H main rotor blades should be extended to include the data from Julian dates 7300 through 8199 so that a year of blade removals is included. The UH-1C/AH-1G blade analyses should be similarly expanded.
- Even though the data are inadequate to determine the probability of scrappage and repair on the 1969 removals, the 9000-9099, 9100-9199, 9200-9299, and 9300-9365 periods of removal data should be examined to determine whether the ratio of external to part cause removals and the MTR's are significantly different. These periods, compared with the similar periods in 1968, had a much lower combat rate that could affect the results of the analysis by showing that the support costs are decreasing. If this is so then the cost targets for a more reparable blade or a throwaway blade would be lower and more difficult to achieve.

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APPENDIX A

DEFINITIONS

1. Reasons for Removal

When components are removed from an aircraft for repair or replacement the data records prepared include a code for the reason for removal. The reasons for removal are grouped into four major cause classes for analysis purposes. They are:

- Part Causes
- External Causes
- No Failure Causes
- Unknown Causes

2. Part Causes

All reasons for removal that are the result of blade deterioration, i.e., excessive wear, bond separation, corrosion or blade unbalance, are grouped into the part cause classification.

3. External Causes

All reasons for removal that are the result of external forces damaging the blade or are due to stressing the blade beyond its specified limits are grouped into the external cause classification.

4. No Failure Causes

Reasons for removal that are "time change" or that are "other than for replacement or repair" are grouped into the "no failure" cause classification.

5. Unknown Causes

Records where reasons for removal are unstated or reasons that are inconsistent with blade removal, e.g., fuse blown, poor focus, etc., are grouped into the unknown cause classification.

6. Allowable Operating Time (AOT)

This is the number of flight hours that the blade is permitted to be used and still have an adequate fatigue life safety margin.

7. Mean-Time-To-Removal (MTR)

This value is the sum of the flight hours at removal for all blades divided by the number of blades removed. The MTR value will always be less than or equal to the AOT.

$$MTR = \frac{\sum_{i=1}^{i=n} t_i}{n} \quad (1)$$

where

t_i = The total flight hours on the i th blade at removal

n = The number of blades removed

8. Mean-Time-Between-Removals (MTBR)

The MTBR for main rotor blades is twice the sum of the flight hours of the group of aircraft from which the blades were removed divided by the number of blades removed during those flight hours.

$$MTBR = \frac{2 \sum_{j=1}^{j=m} t_j}{n} \quad (2)$$

where

t_j = The total flight hours of the j th aircraft

m = The number of aircraft in the group

n = The number of blades removed

9. Improved Blades

Improved blades are blades with cobalt leading edge abrasion strips, nonperforated honeycomb, improved bonding, sealed surfaces, etc. These are all UH-1C/AH-1G blades and all UH-1D/H blades with serial numbers A2-2400 and subsequent.

APPENDIX B

REASONS FOR REMOVAL
AND SCRAPPAGE

TABLE B-I. MAIN ROTOR BLADE REMOVAL REASONS

Reason For Removal	TAERS	RRAD OSM634
<u>ALL CAUSES</u>		
<u>I. PART CAUSES</u>		
A. <u>Excessive Vibration</u>		
Beyond specified tolerance	X	X
Can't balance		X
Erratic	X	X
Excessive vibration	X	X
Fluctuates, unstable	X	
Improper adjustment	X	
Improper alignment	X	
Improper contour	X	
Improper tracking	X	
Improper weight	X	
Mismatched	X	X
Out of adjustment	X	
Out of position	X	
Unable to adjust limits	X	
Unbalanced	X	
Unstable	X	
B. <u>Deterioration</u>		
Brittle	X	
Burst	X	
Cracked	X	X
Deteriorated	X	X
Flaking	X	
Loose rivets		X
Loose trim tabs		X
Noisy		X
C. <u>Bonding Failure</u>		
Bond separation		X
Delaminated	X	X
Internal failure	X	
Loose	X	X
Poor bonding	X	X

TABLE B-I (Cont'd)

Reason For Removal	TAERS	RRAD OSM 634
I. <u>PART CAUSES</u> (Cont'd)		
D. <u>Excessive Wear</u>		
Brush failure/worn excessively	X	
Erosion		X
Internal failure		X
Pitted	X	X
Split		X
Worn excessively	X	X
E. <u>Corrosion</u>		
Corroded	X	
Deposits	X	X
Leaking	X	X
Moisture saturation	X	
Rust or corrosion		X
F. <u>Other</u>		
Manufacturing defect		X
II. <u>EXTERNAL CAUSES</u>		
A. <u>Foreign Object Damage</u>		
Battle damage (combat damage)	X	X
Bent	X	X
Broken	X	X
Buckled	X	X
Chipped	X	
Collapsed	X	X
Cut	X	X
Damaged part, chip, nick, etc.		X
Dented	X	X
Foreign object damage	X	X
Grooved	X	
Holes punched		X
Mutilated		X
Nicked	X	
Punctured	X	
Scored	X	
Torn	X	
B. <u>Overstressed</u>		
Broken weights		X
Crash damage	X	X
Hard landing		X
Hit tree		X
Jammed		X
Overspeed	X	

TABLE B-I (Cont'd)

Reason For Removal	TAERS	RRAD OSM 634
II. <u>EXTERNAL CAUSES</u>		
B. <u>Overstressed</u> (Cont'd)		
Overstressed	X	X
Overtorque		X
RPM out of limit		X
Sudden stoppage	X	X
Warped	X	X
C. <u>Heat Damage</u>		
Blistered	X	X
Burned	X	
Heat Damage	X	X
D. <u>Maintenance and Shipping Damage</u>		
Bad patch, rivet, mod, tab, etc.		X
Damaged in shipment		X
Improper handling		X
Improperly installed	X	
E. <u>Other</u>		
Failure caused by other component failures	X	
III. <u>NO FAILURE CAUSES</u>		
A. <u>Time Change</u>		
Allowable operating time	X	X
B. <u>Other</u>		
Inspect, evaluate, or repair		X
Lost or missing		X
No failure		X
Scheduled maintenance		X
Wrong part		X
IV. <u>UNKNOWN CAUSES</u>		

TABLE B-II. REASONS FOR SCRAPPAGE OF MAIN
ROTOR BLADES AT BHC AND RRAD

<u>Reason for Scrappage</u>	
<u>ALL CAUSES</u>	
I.	<u>PART CAUSES</u>
A.	<u>Imbalance</u> Beyond specified tolerance Bushings out of alignment Can't balance Tip or edge heavy Weights loose
B.	<u>Deterioration</u> Cracked Rough Worn
C.	<u>Bonding Failure</u> Bonding failure Core separation Delaminated Separated Void
D.	<u>Corrosion</u> Corroded
E.	<u>Water Contamination</u> Water in blade
II.	<u>EXTERNAL CAUSES</u>
A.	<u>Foreign Object Damage</u> Bullet holes Creased Cut Damaged Dent Foreign object damage Holes Scored Torn
B.	<u>Overstressed</u> Bent Bowed Broken Buckled Crash damaged

TABLE B-II (Cont'd)

<u>Reason for Scrappage</u>	
II.	<u>EXTERNAL CAUSES</u>
	B. <u>Overstressed</u> (Cont'd)
	Crushed core
	Distorted
	Mutilated
	Warped
III.	<u>NO FAILURE CAUSES</u>
	A. <u>Time Change</u>
	Allowable operating time
IV.	<u>OTHER CAUSES</u>
	A. <u>Unknown</u>

APPENDIX C

METHOD TO DETERMINE COST TARGETS FOR THROWAWAY BLADES

1. Analysis Method

To determine the cost target for throwaway blades in dollars per blade, values for the following functions should be established.

- The maximum desired aircraft main rotor blade support cost in dollars per flight hour
- The blade mean-time-to-removal for part and external causes at the location where the majority of the aircraft are stationed
- The percent of the blades removed for part and external causes that can be repaired at the point of removal
- The life cycle of the aircraft
- The number of blades per aircraft
- The cost of transporting the blades from the factory to the aircraft
- The average cost of removing and replacing a blade
- The average cost of repairing a blade at the point of removal

An equation to compute the blade cost target was developed from equations (3), (5) and (6) in Section III of this report.

$$C_T = \frac{1}{g} \left[\frac{100 C_{bs} L \widehat{MTR}}{n (L - \widehat{MTR})} - g \left(e C_{sa} + f C_{ss} \right) \right. \\ \left. - 100 C_m (T_{r1} + T_i) + j C_m T_{r2} \right] \quad (1)$$

where

C_T = The blade cost target, the cost of the new blade at the factory in dollars per blade

C_{b_s} = Blade support cost in dollars per flight hour

L = Aircraft life cycle in flight hours

\overline{MTR} = The mean-time-to-removal for repair or replacement in blade hours

n = The number of blades in the rotor

C_{s_a} = The dollar cost of shipping a blade to CONUS using air transportation

C_{s_s} = The dollar cost of shipping a blade to CONUS using surface transportation

e = The fraction of the blades shipped from CONUS that are transported by air

f = The fraction of the blades shipped from CONUS by surface transportation

C_m = The manhour cost of organizational maintenance personnel

T_{r_1} = The time in manhours to remove a blade assembly

T_{r_2} = The time in manhours to repair a blade at the removal area

T_i = The time in manhours to install the blade assembly

g = The percentage of removed blades replaced by new blades

j = The percentage of the blades removed that are repaired by the using organization

For equation (1):

$$e + f = 1 \quad (2)$$

$$g + j = 100 \quad (3)$$

2. Examples

Two throwaway blade cost targets for the UH-1D/H and the UH-1C/AH-1G aircraft are computed to show how this method is used. The first target is based on a support program where limited blade repair is accomplished at the point of removal. The second is based on no repair. Table C-I presents the input values used for the computations.

TABLE C-I. FUNCTION VALUES FOR THE
EXAMPLE COMPUTATIONS

Functions	Example			
	1	2	3	4
Aircraft	UH-1D/H	UH-1D/H	UH-1C/ AH-1G	UH-1C/ AH-1G
C_{bs} - /flt hr	\$9.84	\$9.84	\$14.61	\$14.61
L - flt hrs	5000	5000	5000	5000
MTR - hrs	408.8	408.8	315.5	315.5
n	2	2	2	2
C_{sa}	\$114	\$114	\$114	\$114
C_{ss}	\$82	\$82	\$82	\$82
e	0	0	0	0
f	1	1	1	1
C_m	\$3.50	\$3.50	\$3.50	\$3.50
T_{r1} - hrs	3.73	3.73	3.72	3.72
T_{r2} - hrs	6.00	6.00	6.50	6.50
T_i - hrs	3.73	3.73	3.72	3.72
g	88.2%	100.0%	83.9%	100.0%
j	11.8%	0.0%	16.1%	0.0%

Table C-II presents the results of the computations.

TABLE C-II. RESULTS OF THE EXAMPLE COMPUTATIONS

	<u>Model</u>	
	<u>UH-1D/H</u>	<u>UH-1C/AH-1G</u>
Cost target of a blade capable of limited repairs at the point of removal (ground transportation, examples 1 and 3)	\$2360.85	\$2814.92
Cost target of a blade that is completely nonreparable (ground transportation, examples 2 and 4)	\$2082.27	\$2351.91

APPENDIX D

DETAILS OF REASON FOR REMOVAL/MTR/MTBR ANALYSIS OF TAERS DA2410 COMPONENT REMOVAL, AND REPAIR/OVERHAUL (AND INSTALLATION) RECORD DATA

TABLE D-1. REASON FOR REMOVAL/MTR ANALYSIS
OF TAERS DA2410 D/H Main Rotor
BLADE REMOVAL DATA

Blades From Aircraft Model(s): UH-1D/H

Part No. 204-011-250-5

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>8,222</u>	<u>453.5</u>	<u>100.00</u>
I. <u>PART CAUSES</u>	<u>2,141</u>	<u>546.7</u>	<u>26.04</u>
A. <u>Excessive Vibration</u>	<u>521</u>	<u>355.1</u>	<u>6.34</u>
Beyond specified tolerance	27	443.7	0.33
Excessive vibration	173	298.1	2.10
Fluctuates, unstable	6	432.8	0.07
Improper adjustment	4	895.5	0.05
Improper alignment	1	499.0	0.01
Improper tracking	34	277.9	0.41
Improper weight	5	241.6	0.06
Mismatched	34	366.0	0.41
Out of adjustment	21	498.9	0.26
Out of position	1	178.0	0.01
Unable to adjust limits	119	401.4	1.45
Unbalanced	73	367.4	0.89
Unstable	23	278.3	0.28
B. <u>Deterioration</u>	<u>698</u>	<u>597.3</u>	<u>8.49</u>
Brittle	8	428.8	0.10
Burst	7	994.0	0.09
Cracked	608	585.6	7.39
Deteriorated	69	671.3	0.84
Flaking	6	689.5	0.07
C. <u>Bonding Failure</u>	<u>477</u>	<u>580.8</u>	<u>5.80</u>
Delaminated	128	582.3	1.56
Internal failure	37	530.5	0.45
Loose	17	524.1	0.21
Poor bonding	295	589.6	3.59
D. <u>Excessive Wear</u>	<u>316</u>	<u>657.4</u>	<u>3.84</u>
Brush failure/worn excessively	13	299.7	0.16
Pitted	26	563.4	0.32
Worn excessively	277	682.9	3.37
E. <u>Corrosion</u>	<u>129</u>	<u>648.9</u>	<u>1.57</u>
Corroded	76	749.0	0.92
Deposits	7	339.0	0.09
Leaking	28	486.2	0.34
Moisture saturation	18	599.1	0.22

TABLE D-I (Cont'd)

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
II. <u>EXTERNAL CAUSES</u>	<u>5,188</u>	<u>398.8</u>	<u>63.10</u>
A. <u>Foreign Object Damage</u>	<u>4,425</u>	<u>398.5</u>	<u>53.82</u>
Battle damage (combat damage)	752	386.8	9.15
Bent	74	409.8	0.90
Broken	74	426.3	0.90
Buckled	37	422.6	0.45
Chipped	23	433.8	0.28
Collapsed	3	68.6	0.04
Cut	184	346.5	2.24
Dented	1,198	437.6	14.57
Foreign object damage	754	416.5	9.17
Grooved	10	328.7	0.12
Nicked	49	406.7	0.60
Punctured	883	357.8	10.74
Scored	9	652.0	0.11
Torn	375	366.8	4.56
B. <u>Overstressed</u>	<u>742</u>	<u>400.4</u>	<u>9.02</u>
Crash damage	162	485.1	1.97
Overspeed	234	392.6	2.85
Overstressed	118	297.8	1.44
Sudden stoppage	196	412.5	2.38
Warped	32	330.5	0.39
C. <u>Heat Damage</u>	<u>15</u>	<u>349.7</u>	<u>0.18</u>
Blistered	9	394.4	0.11
Burned	5	238.4	0.06
Heat damage	1	504.0	0.01
D. <u>Maintenance and Shipping Damage</u>	<u>1</u>	<u>106.0</u>	<u>0.01</u>
Improperly installed	1	106.0	0.01
E. <u>Other</u>	<u>5</u>	<u>583.6</u>	<u>0.06</u>
Failure caused by other component failures	5	583.6	0.06
III. <u>NC FAILURE CAUSES</u>	<u>87</u>	<u>1,658.8</u>	<u>1.06</u>
A. <u>Time Change</u>	<u>87</u>	<u>1,658.8</u>	<u>1.06</u>
Allowable operating time	87	1,658.8	1.06
IV. <u>UNKNOWN CAUSES</u>	<u>806</u>	<u>428.4</u>	<u>9.80</u>

TABLE D-II. REASON FOR REMOVAL/MTR ANALYSIS
OF TAERS DA2410 C/G MAIN ROTOR
BLADE REMOVAL DATA

Blades From Aircraft Model(s): UH-1G/AH-1G

Part No. 540-011-001-5

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>2,204</u>	<u>337.7</u>	<u>100.00</u>
I. <u>PART CAUSES</u>	<u>532</u>	<u>341.8</u>	<u>24.14</u>
A. <u>Excessive Vibration</u>	<u>175</u>	<u>258.5</u>	<u>7.94</u>
Beyond specified tolerance	6	400.3	0.27
Erratic	2	51.0	0.09
Excessive vibration	76	162.6	3.45
Fluctuates, unstable	3	390.6	0.14
Improper alignment	2	487.5	0.09
Improper contour	1	270.0	0.05
Improper tracking	7	232.0	0.32
Improper weight	1	510.0	0.75
Mismatched	8	376.1	0.56
Out of adjustment	9	403.6	0.41
Unable to adjust limits	36	280.5	1.63
Unbalanced	17	391.3	0.77
Unstable	7	347.4	0.32
B. <u>Deterioration</u>	<u>148</u>	<u>393.7</u>	<u>6.72</u>
Brittle	3	163.6	0.14
Cracked	139	401.0	6.31
Deteriorated	5	341.8	0.23
Flaking	1	330.0	0.05
C. <u>Bonding Failure</u>	<u>118</u>	<u>341.6</u>	<u>5.35</u>
Delaminated	23	288.4	1.04
Internal failure	15	710.9	0.68
Loose	12	135.8	0.54
Poor bonding	68	314.4	3.09
D. <u>Excessive Wear</u>	<u>60</u>	<u>412.4</u>	<u>2.72</u>
Brush failure/worn excessively	3	386.6	0.14
Pitted	1	66.0	0.05
Worn excessively	56	419.9	2.54
E. <u>Corrosion</u>	<u>31</u>	<u>427.5</u>	<u>1.41</u>
Corroded	22	414.0	1.00
Deposits	4	368.2	0.18
Leaking	3	618.6	0.14
Moisture saturation	2	406.5	0.09

TABLE D-II. (Cont'd)

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
II. EXTERNAL CAUSES	<u>1,431</u>	<u>283.6</u>	<u>64.93</u>
A. Foreign Object Damage	<u>1,221</u>	<u>285.4</u>	<u>55.40</u>
Battle damage (combat damage)	345	270.5	15.65
Bent	17	359.1	0.77
Broken	11	306.6	0.50
Buckled	6	143.1	0.27
Chipped	9	387.0	0.41
Cut	36	353.2	1.63
Dented	151	287.8	6.85
Foreign object damage	237	264.4	10.75
Grooved	3	76.3	0.14
Nicked	18	320.7	0.82
Punctured	357	292.4	16.20
Scored	1	432.0	0.05
Torn	30	385.8	1.36
B. Overstressed	<u>202</u>	<u>273.1</u>	<u>9.17</u>
Crash damage	48	260.2	2.18
Overspeed	60	279.4	2.72
Overstressed	28	194.0	1.27
Sudden stoppage	54	305.2	2.45
Warped	12	333.5	0.54
C. Heat Damage	<u>6</u>	<u>201.0</u>	<u>0.27</u>
Blistered	3	357.3	0.14
Burned	1	84.0	0.05
Heat damage	2	25.0	0.09
D. Maintenance and Shipping Damage	<u>2</u>	<u>488.5</u>	<u>0.09</u>
Improperly installed	2	488.5	0.09
III. NO FAILURE CAUSES	<u>105</u>	<u>985.7</u>	<u>4.76</u>
A. Time Change	<u>105</u>	<u>985.7</u>	<u>4.76</u>
Allowable operating time	105	985.7	4.76
IV. UNKNOWN CAUSES	<u>136</u>	<u>388.7</u>	<u>6.17</u>

TABLE D-III. REASON FOR REMOVAL/MTR ANALYSIS
OF TAERS DA2410 VIETNAM D/H
MAIN ROTOR BLADE REMOVAL DATA

Blades From Aircraft Model(s): UH-1D/H

Part No. 204-011-250-5

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>4,609</u>	<u>408.8</u>	<u>100.00</u>
1. <u>PART CAUSES</u>	<u>1,069</u>	<u>519.5</u>	<u>23.19</u>
A. <u>Excessive Vibration</u>	<u>187</u>	<u>396.5</u>	<u>4.06</u>
Beyond specified tolerance	17	459.5	0.26
Excessive vibration	41	469.9	0.89
Fluctuates, unstable	4	403.7	0.09
Improper adjustment	1	776.0	0.02
Improper tracking	17	257.7	0.37
Improper weight	3	206.0	0.07
Mismatched	23	333.9	0.50
Out of adjustment	9	416.1	0.20
Out of position	1	178.0	0.02
Unable to adjust limits	43	486.5	0.93
Unbalanced	28	284.4	0.61
Unstable	5	297.6	0.11
B. <u>Deterioration</u>	<u>375</u>	<u>538.8</u>	<u>8.14</u>
Brittle	5	515.4	0.11
Burst	2	806.5	0.04
Cracked	316	516.3	6.86
Deteriorated	48	675.3	1.04
Flaking	4	576.2	0.09
C. <u>Bonding Failure</u>	<u>238</u>	<u>515.5</u>	<u>5.16</u>
Delaminated	57	512.8	1.24
Internal failure	15	353.3	0.33
Loose	5	399.2	0.11
Poor bonding	161	535.1	3.49
D. <u>Excessive Wear</u>	<u>177</u>	<u>594.2</u>	<u>3.84</u>
Brush failure/worn excessively	12	293.1	0.26
Pitted	19	551.1	0.41
Worn excessively	146	624.5	3.17
E. <u>Corrosion</u>	<u>92</u>	<u>557.5</u>	<u>2.00</u>
Corroded	58	668.8	1.26
Deposits	5	315.6	0.11
Leaking	19	412.3	0.41
Moisture saturation	10	308.2	0.22

TABLE D-III (Cont'd)

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
II. <u>EXTERNAL CAUSES</u>	<u>3,092</u>	<u>369.4</u>	<u>67.09</u>
A. <u>Foreign Object Damage</u>	<u>2,616</u>	<u>373.3</u>	<u>56.76</u>
Battle damage (combat damage)	512	384.4	11.11
Bent	41	391.3	0.89
Broken	46	388.4	1.00
Buckled	13	425.8	0.28
Chipped	15	381.0	0.33
Collapsed	2	100.0	0.04
Cut	136	344.6	2.95
Dented	725	413.4	15.73
Foreign object damage	373	371.5	8.09
Grooved	7	316.2	0.15
Nicked	22	357.2	0.48
Punctured	493	337.3	10.70
Scored	7	680.5	0.15
Torn	224	305.6	4.86
B. <u>Overstressed</u>	<u>464</u>	<u>348.5</u>	<u>10.07</u>
Crash damage	86	365.6	1.87
Overspeed	143	369.1	3.10
Overstressed	75	276.6	1.63
Sudden stoppage	143	355.8	3.10
Warped	17	342.1	0.37
C. <u>Heat Damage</u>	<u>8</u>	<u>333.1</u>	<u>0.17</u>
Blistered	5	393.6	0.11
Burned	2	96.5	0.04
Heat damage	1	504.0	0.02
D. <u>Other</u>	<u>4</u>	<u>179.5</u>	<u>0.09</u>
Failure caused by other component failures	4	179.5	0.09
III. <u>NO FAILURE CAUSES</u>	<u>16</u>	<u>749.5</u>	<u>0.35</u>
A. <u>Time Change</u>	<u>16</u>	<u>749.5</u>	<u>0.35</u>
Allowable operating time	16	749.5	0.35
IV. <u>UNKNOWN CAUSES</u>	<u>432</u>	<u>404.7</u>	<u>9.37</u>

TABLE D-IV. REASON FOR REMOVAL/MTR ANALYSIS
OF TAERS DA2410 VIETNAM C/G
MAIN ROTOR BLADE REMOVAL DATA

Blades From Aircraft Model(s): UH-1C/AH-1C

Part No. 540-011-001-5

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>1,288</u>	<u>315.5</u>	<u>100.00</u>
I. <u>PART CAUSES</u>	<u>302</u>	<u>371.1</u>	<u>23.45</u>
A. <u>Excessive Vibration</u>	<u>86</u>	<u>324.6</u>	<u>6.68</u>
Beyond specified tolerance	5	360.2	0.39
Excessive vibration	23	304.1	1.79
Fluctuates, unstable	1	268.0	0.08
Improper alignment	1	201.0	0.08
Improper contour	1	270.0	0.08
Improper tracking	6	248.5	0.47
Mismatched	4	390.0	0.31
Out of adjustment	7	511.2	0.54
Unable to adjust limits	22	281.4	1.71
Unbalanced	12	375.6	0.93
Unstable	4	263.2	0.31
B. <u>Deterioration</u>	<u>86</u>	<u>410.9</u>	<u>6.68</u>
Brittle	1	51.0	0.08
Cracked	81	415.8	6.29
Deteriorated	4	401.5	0.31
C. <u>Bonding Failure</u>	<u>70</u>	<u>340.3</u>	<u>5.43</u>
Delaminated	13	295.2	1.01
Internal failure	8	569.6	0.62
Loose	2	321.0	0.16
Poor bonding	47	314.5	3.65
D. <u>Excessive Wear</u>	<u>39</u>	<u>418.3</u>	<u>3.03</u>
Brush failure/worn excessively	1	662.0	0.08
Worn excessively	38	411.8	2.95
E. <u>Corrosion</u>	<u>21</u>	<u>412.7</u>	<u>1.63</u>
Corroded	16	406.5	1.24
Deposits	2	445.5	0.16
Leaking	2	446.0	0.16
Moisture saturation	1	380.0	0.08
II. <u>EXTERNAL CAUSES</u>	<u>886</u>	<u>271.7</u>	<u>68.79</u>
A. <u>Foreign Object Damage</u>	<u>756</u>	<u>279.7</u>	<u>58.70</u>
Battle damage (combat damage)	242	262.2	18.79
Bent	11	260.5	0.85
Broken	7	336.5	0.54
Buckled	4	155.2	0.31

TABLE D-IV (Cont'd)

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
II. EXTERNAL CAUSES			
A. Foreign Object Damage (Cont'd)			
Chipped	4	386.2	0.31
Cut	24	325.2	1.86
Dented	88	283.5	6.83
Foreign object damage	158	263.2	12.27
Grooved	3	76.3	0.23
Nicked	14	338.4	1.09
Punctured	185	291.8	14.36
Scored	1	432.0	0.08
Torn	15	455.6	1.16
B. Overstressed	125	223.8	9.70
Crash damage	34	248.0	2.64
Overspeed	38	242.1	2.95
Overstressed	18	154.5	1.40
Sudden stoppage	27	212.3	2.10
Warped	8	227.8	0.62
C. Heat Damage	3	117.7	0.23
Blistered	1	303.0	0.08
Heat damage	2	25.0	0.16
D. Maintenance and Shipping Damage	2	488.5	0.16
Improperly installed	2	488.5	0.16
III. NO FAILURE CAUSES	30	934.1	2.33
A. Time Change	30	934.1	2.33
Allowable operating time	30	934.1	2.33
IV. UNKNOWN CAUSES	70	365.2	5.42

TABLE D-V. REASON FOR REMOVAL/MTR ANALYSIS
OF TAERS DA2410 CONUS D/H
MAIN ROTOR BLADE REMOVAL DATA

Blades From Aircraft Model(s): UH-1D/H

Part No. 201-011-250-5

Reason For Removal	Records With Part Time		Percent Of All Causes
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>333</u>	<u>993.4</u>	<u>100.00</u>
<u>I. PART CAUSES</u>	<u>148</u>	<u>994.5</u>	<u>44.44</u>
A. <u>Excessive Vibration</u>	<u>35</u>	<u>532.2</u>	<u>10.51</u>
Beyond specified tolerance	2	662.5	0.60
Excessive vibration	12	226.3	3.60
Mismatched	1	161.0	0.30
Out of adjustment	2	610.5	0.60
Unable to adjust limits	8	661.8	2.40
Unbalanced	8	970.3	2.40
Unstable	2	74.0	0.60
B. <u>Deterioration</u>	<u>56</u>	<u>1,140.5</u>	<u>16.82</u>
Burst	1	436.0	0.30
Cracked	52	1,136.4	15.62
Deteriorated	3	1,100.6	0.90
C. <u>Bonding Failure</u>	<u>36</u>	<u>949.3</u>	<u>10.81</u>
Delaminated	6	1,000.3	1.80
Internal failure	1	1,732.0	0.30
Loose	4	858.5	1.20
Poor bonding	25	920.3	7.51
D. <u>Excessive Wear</u>	<u>18</u>	<u>1,556.4</u>	<u>5.41</u>
Worn excessively	18	1,556.4	5.41
E. <u>Corrosion</u>	<u>3</u>	<u>835.3</u>	<u>0.90</u>
Deposits	1	222.0	0.30
Leaking	2	1,142.0	0.60
<u>II. EXTERNAL CAUSES</u>	<u>134</u>	<u>765.6</u>	<u>40.24</u>
A. <u>Foreign Object Damage</u>	<u>76</u>	<u>796.0</u>	<u>22.82</u>
Broken	1	1,591.0	0.30
Buckled	1	196.0	0.30
Chipped	3	673.7	0.90
Dented	51	838.4	15.32
Foreign object damage	4	487.8	1.20
Nicked	3	672.3	0.90
Punctured	4	559.8	1.20
Torn	9	858.0	2.70
B. <u>Overstressed</u>	<u>58</u>	<u>725.7</u>	<u>17.41</u>
Crash damage	26	940.4	7.81
Overspeed	10	533.0	3.00

TABLE D-V (Cont'd)

Reason For Removal	Records With Part Time		Percent Of All Causes
	Number	MTR (Hours)	
II. <u>EXTERNAL CAUSES</u>			
B. <u>Overstressed</u> (Cont'd)			
Overstressed	6	348.0	1.80
Sudden stoppage	14	691.5	4.20
Warped	2	272.0	0.60
III. <u>NO FAILURE CAUSES</u>	<u>28</u>	<u>2,396.9</u>	<u>8.41</u>
A. <u>Time Change</u>	<u>28</u>	<u>2,396.9</u>	<u>8.41</u>
Allowable operating time	<u>28</u>	<u>2,396.9</u>	<u>8.41</u>
IV. <u>UNKNOWN CAUSES</u>	<u>23</u>	<u>604.6</u>	<u>6.91</u>

TABLE D-VI. REASON FOR REMOVAL/MTR ANALYSIS
OF TAERS DA2410 CONUS C/G
MAIN ROTOR BLADE REMOVAL DATA

Blades From Aircraft Model(s): UH-1C/AH-1G

Part No. 540-011-001-5

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>53</u>	<u>475.7</u>	<u>100.00</u>
I. <u>PART CAUSES</u>	<u>18</u>	<u>455.3</u>	<u>33.96</u>
A. <u>Excessive Vibration</u>	<u>8</u>	<u>509.1</u>	<u>15.09</u>
Excessive vibration	7	359.0	3.77
Unable to adjust limits	2	668.5	3.77
Unbalanced	1	639.0	1.89
Unstable	3	459.6	5.66
B. <u>Deterioration</u>	<u>5</u>	<u>544.8</u>	<u>9.43</u>
Cracked	5	544.8	9.43
C. <u>Bonding Failure</u>	<u>2</u>	<u>97.0</u>	<u>3.77</u>
Delaminated	1	16.0	1.89
Poor bonding	1	178.0	1.89
D. <u>Excessive Wear</u>	<u>2</u>	<u>371.0</u>	<u>3.77</u>
Worn excessively	2	371.0	3.77
E. <u>Corrosion</u>	<u>1</u>	<u>462.0</u>	<u>1.89</u>
Corroded	1	462.0	1.89
II. <u>EXTERNAL CAUSES</u>	<u>22</u>	<u>290.2</u>	<u>41.51</u>
A. <u>Foreign Object Damage</u>	<u>16</u>	<u>232.0</u>	<u>30.19</u>
Buckled	1	126.0	1.89
Chipped	1	72.0	1.89
Cut	1	395.0	1.89
Dented	9	192.4	16.98
Foreign object damage	1	18.0	1.89
Torn	3	456.3	5.66
B. <u>Overstressed</u>	<u>6</u>	<u>445.3</u>	<u>11.32</u>
Overspeed	6	445.3	11.32
III. <u>NO FAILURE CAUSES</u>	<u>10</u>	<u>994.7</u>	<u>18.87</u>
A. <u>Time Change</u>	<u>10</u>	<u>994.7</u>	<u>18.87</u>
Allowable operating time	10	994.7	18.87
IV. <u>UNKNOWN CAUSES</u>	<u>3</u>	<u>229.3</u>	<u>5.66</u>

TABLE D-VII. REASON FOR REMOVAL/MTR/MTBR
ANALYSIS OF A SELECTED SAMPLE
OF TAHS DA2410 VIETNAM U/H
MAIN ROTOR BLADE REMOVAL DATA

Blades From Aircraft Model(s): UH-1D/H

Part No. 204-011-250-5

Reason For Removal	Records With Part Time		MTBR (Hours)
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>136</u>	<u>514.3</u>	<u>1,063</u>
<u>I. PART CAUSES</u>	<u>26</u>	<u>601.0</u>	<u>5,560</u>
A. <u>Excessive Vibration</u>	<u>2</u>	<u>98.0</u>	<u>72,278</u>
Unable to adjust limits	<u>2</u>	<u>98.0</u>	<u>72,278</u>
B. <u>Deterioration</u>	<u>8</u>	<u>565.6</u>	<u>18,070</u>
Cracked	<u>8</u>	<u>565.6</u>	<u>18,070</u>
C. <u>Bonding Failure</u>	<u>15</u>	<u>667.6</u>	<u>9,637</u>
Delaminated	<u>6</u>	<u>269.0</u>	<u>24,093</u>
Internal failure	<u>3</u>	<u>856.7</u>	<u>48,185</u>
Poor bonding	<u>6</u>	<u>471.7</u>	<u>24,093</u>
D. <u>Excessive Wear</u>	<u>1</u>	<u>891.0</u>	<u>144,556</u>
Pitted	<u>1</u>	<u>891.0</u>	<u>144,556</u>
E. <u>Corrosion</u>	<u>0</u>	<u>0.0</u>	<u>-</u>
F. <u>Other</u>	<u>0</u>	<u>0.0</u>	<u>-</u>
<u>II. EXTERNAL CAUSES</u>	<u>109</u>	<u>494.8</u>	<u>1,326</u>
A. <u>Foreign Object Damage</u>	<u>102</u>	<u>484.8</u>	<u>1,417</u>
Battle damage (combat damage)	<u>21</u>	<u>598.9</u>	<u>6,884</u>
Bent	<u>1</u>	<u>495.0</u>	<u>144,556</u>
Broken	<u>1</u>	<u>235.0</u>	<u>144,556</u>
Buckled	<u>1</u>	<u>218.0</u>	<u>144,556</u>
Chipped	<u>1</u>	<u>600.0</u>	<u>144,556</u>
Cut	<u>3</u>	<u>216.3</u>	<u>48,185</u>
Dented	<u>28</u>	<u>433.2</u>	<u>5,163</u>
Foreign object damage	<u>17</u>	<u>697.4</u>	<u>8,503</u>
Punctured	<u>22</u>	<u>370.6</u>	<u>6,571</u>
Torn	<u>7</u>	<u>362.1</u>	<u>20,651</u>
B. <u>Overstressed</u>	<u>7</u>	<u>641.1</u>	<u>20,651</u>
Overspeed	<u>4</u>	<u>467.0</u>	<u>36,139</u>
Overstressed	<u>1</u>	<u>418.1</u>	<u>144,556</u>
Sudden stoppage	<u>2</u>	<u>1,101.0</u>	<u>72,278</u>
C. <u>Heat Damage</u>	<u>0</u>	<u>0.0</u>	<u>-</u>
D. <u>Maintenance and Shipping Damage</u>	<u>0</u>	<u>0.0</u>	<u>-</u>
E. <u>Other</u>	<u>0</u>	<u>0.0</u>	<u>-</u>

TABLE D-VII (Cont'd)

Reason For Removal	Records With Part Time		MTR (Hours)
	Number	MTR (Hours)	
III. <u>NO FAILURE CAUSES</u>	<u>0</u>	<u>0.0</u>	<u>-</u>
IV. <u>UNKNOWN CAUSES</u>	<u>1</u>	<u>385.0</u>	<u>144,556</u>

TABLE D VIII. REASON FOR REMOVAL MTR/MTBR
ANALYSIS OF A SELECTED SAMPLE
OF TAERS DA2410 VIETNAM C/G
MAIN ROTOR BLADE REMOVAL DATA

Blades From Aircraft Model(s): UH-1G/AH-1G Part No. 540-011-001-5

Reason For Removal	Records With Part Time		MTBR (Hours)
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>250</u>	<u>279.1</u>	<u>908</u>
<u>I. PART CAUSES</u>	<u>63</u>	<u>348.3</u>	<u>3,602</u>
A. <u>Excessive Vibration</u>	<u>20</u>	<u>266.0</u>	<u>11,346</u>
Beyond specified tolerance	1	682.0	226,920
Excessive vibration	6	266.0	37,820
Fluctuates, unstable	1	268.0	226,920
Improper tracking	1	405.0	226,920
Out of adjustment	1	49.0	226,920
Unable to adjust limits	8	249.1	28,365
Unbalanced	2	424.0	113,460
B. <u>Deterioration</u>	<u>19</u>	<u>382.7</u>	<u>11,943</u>
Brittle	1	51.0	226,920
Cracked	17	417.9	13,348
Deteriorated	1	121.0	226,920
C. <u>Bonding Failure</u>	<u>17</u>	<u>299.2</u>	<u>13,348</u>
Delaminated	4	265.5	56,730
Internal failure	3	423.3	75,640
Poor bonding	10	275.5	22,692
D. <u>Excessive Wear</u>	<u>3</u>	<u>821.3</u>	<u>75,640</u>
Brush failure/worn excessively	1	662.0	226,920
Worn excessively	2	901.0	113,400
E. <u>Corrosion</u>	<u>4</u>	<u>462.0</u>	<u>56,730</u>
Corroded	3	518.3	75,640
Leaking	1	293.0	226,920
F. <u>Other</u>	<u>0</u>	<u>0.0</u>	<u>-</u>
<u>II. EXTERNAL CAUSES</u>	<u>181</u>	<u>236.7</u>	<u>1,252</u>
A. <u>Foreign Object Damage</u>	<u>141</u>	<u>227.5</u>	<u>1,609</u>
Battle damage (combat damage)	35	173.5	6,483
Bent	3	165.0	75,640
Broken	1	288.0	226,920
Cut	4	415.3	56,730
Dented	15	227.1	15,128
Foreign object damage	18	268.0	12,607
Punctured	62	242.3	3,660
Torn	3	101.3	75,640
B. <u>Overstressed</u>	<u>38</u>	<u>257.7</u>	<u>5,972</u>
Crash damage	4	174.5	56,730

TABLE D-VIII (Cont'd)

Reason For Removal	Records With Part Time		MTR (Hours)
	Number	MTR (Hours)	
II. <u>EXTERNAL CAUSES</u>			
B. <u>Overstressed</u> (Cont'd)			
Overspeed	18	294.6	12,607
Overstressed	1	562.0	226,920
Sudden stoppage	13	189.8	17,455
Warped	2	381.0	113,460
C. <u>Heat Damage</u>	0	0.0	-
D. <u>Maintenance and Shipping Damage</u>	2	488.5	113,460
Improperly installed	2	488.5	113,460
E. <u>Other</u>	0	0.0	-
III. <u>NO FAILURE CAUSES</u>	4	1,184.8	56,730
A. <u>Time Change</u>	4	1,184.8	56,730
Allowable operating time	4	1,184.8	56,730
B. <u>Other</u>	0	0.0	-
IV. <u>UNKNOWN CAUSES</u>	2	123.5	113,460

TABLE D-IX. REASON FOR REMOVAL/MTR/MTBR
ANALYSIS OF A SELECTED SAMPLE
OF TAERS DA2410 CONUS D/H
MAIN ROTOR BLADE REMOVAL DATA

Blades From Aircraft Model(s): UH-1D/H Part No. 204-011-250-5

Reason For Removal	Records With Part Time		MTBR (Hours)
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>16</u>	<u>1,484.1</u>	<u>720</u>
<u>I. PART CAUSES</u>	<u>6</u>	<u>853.8</u>	<u>1,919</u>
A. <u>Excessive Vibration</u>	<u>3</u>	<u>696.0</u>	<u>3,839</u>
Unable to adjust limits	<u>1</u>	<u>1,940.0</u>	<u>11,516</u>
Unstable	<u>2</u>	<u>74.0</u>	<u>5,758</u>
B. <u>Deterioration</u>	<u>3</u>	<u>1,011.7</u>	<u>3,839</u>
Cracked	<u>2</u>	<u>638.0</u>	<u>5,758</u>
Deteriorated	<u>1</u>	<u>1,759.0</u>	<u>11,516</u>
C. <u>Bonding Failure</u>	<u>0</u>	<u>0.0</u>	<u>-</u>
D. <u>Excessive Wear</u>	<u>0</u>	<u>0.0</u>	<u>-</u>
E. <u>Corrosion</u>	<u>0</u>	<u>0.0</u>	<u>-</u>
F. <u>Other</u>	<u>0</u>	<u>0.0</u>	<u>-</u>
<u>II. EXTERNAL CAUSES</u>	<u>4</u>	<u>951.5</u>	<u>2,879</u>
A. <u>Foreign Object Damage</u>	<u>4</u>	<u>951.5</u>	<u>2,879</u>
Dented	<u>4</u>	<u>951.5</u>	<u>2,879</u>
B. <u>Overstressed</u>	<u>0</u>	<u>0.0</u>	<u>-</u>
C. <u>Heat Damage</u>	<u>0</u>	<u>0.0</u>	<u>-</u>
D. <u>Maintenance and Shipping Damage</u>	<u>0</u>	<u>0.0</u>	<u>-</u>
E. <u>Other</u>	<u>0</u>	<u>0.0</u>	<u>-</u>
<u>III. NO FAILURE CAUSES</u>	<u>6</u>	<u>2,469.3</u>	<u>1,919</u>
A. <u>Time Change</u>	<u>6</u>	<u>2,469.3</u>	<u>1,919</u>
Allowable operating time	<u>6</u>	<u>2,469.3</u>	<u>1,919</u>
B. <u>Other</u>	<u>0</u>	<u>0.0</u>	<u>-</u>
<u>IV. UNKNOWN CAUSES</u>	<u>0</u>	<u>0.0</u>	<u>-</u>

TABLE D-X. REASON FOR REMOVAL DISTRIBUTION COMPARISON
OF THE TAERS DATA FILES AND THE DATA
SAMPLES SELECTED FOR MTBR ANALYSIS

Reason for Removal	UH-1G/AH-1G - VIETNAM						UH-1H - VIETNAM						UH-1H - JAPAN					
	All Ships			Monitored Ships			All Ships			Monitored Ships			All Ships			Monitored Ships		
	No.	MTR	%	No.	MTR	%	No.	MTR	%	No.	MTR	%	No.	MTR	%	No.	MTR	%
ALL CAUSES	2,204	337.2	100.00	250	279.1	100.00	8,222	53.5	100.00	136	514.3	100.00	333	333	100.00	333	333	100.00
I. PART CAUSES	532	341.8	24.14	63	348.3	25.20	2,141	546.7	20.04	26	601.0	27.00	229	229	100.00	229	229	100.00
A. Excessive Vibration	175	258.5	7.94	20	266.0	9.00	52	355.1	6.34	2	48.0	1.00	31	537	100.00	31	537	100.00
B. Deterioration	148	393.7	6.72	19	382.7	7.60	698	597.3	7.47	8	565.0	5.99	56	565	100.00	56	565	100.00
C. Bonding Failure	118	341.6	5.35	17	299.2	6.60	477	380.8	5.80	15	467.6	1.02	34	467.6	100.00	34	467.6	100.00
D. Excessive Wear	60	412.4	2.72	3	921.3	1.20	316	657.4	3.94	1	491.0	0.73	1	491.0	100.00	1	491.0	100.00
E. Corrosion	31	427.5	1.41	4	462.0	1.60	144	646.4	1.57	1	491.0	0.73	1	491.0	100.00	1	491.0	100.00
II. EXTERNAL CAUSES	1,431	253.0	64.93	181	236.7	72.40	5,153	395.9	63.10	107	494.8	80.14	134	765.4	100.00	134	765.4	100.00
A. Foreign Object Damage	1,222	285.4	55.40	141	227.5	56.40	4,425	398.5	53.82	102	494.8	75.00	76	765.4	100.00	76	765.4	100.00
B. Overstressed	202	273.1	9.17	38	257.7	15.20	742	400.4	9.02	1	64.0	0.12	58	765.4	100.00	58	765.4	100.00
C. Heat Damage	6	201.0	0.27	0	-	0.00	15	349.7	0.44	1	64.0	0.12	1	64.0	100.00	1	64.0	100.00
D. Maintenance and Shipping Damage	2	488.5	0.09	2	488.5	0.80	1	106.0	0.04	1	64.0	0.12	1	64.0	100.00	1	64.0	100.00
E. Other	0	-	0.00	0	-	0.00	5	593.4	0.06	1	64.0	0.12	1	64.0	100.00	1	64.0	100.00
III. NO FAILURE CAUSES	105	985.7	4.76	4	1,184.8	1.60	87	1,158.8	1.04	0	-	-	0	-	-	0	-	-
A. Time Change	105	985.7	4.76	4	1,184.8	1.60	87	1,158.8	1.04	0	-	-	0	-	-	0	-	-
IV. UNKNOWN CAUSES	136	388.2	6.17	2	123.5	0.60	905	428.4	7.80	1	353.0	0.73	23	353.0	100.00	23	353.0	100.00

* Improved Blades Only
 ** FY '65 and '66 UH-1G and FY '65 and FY '67 AH-1G Aircraft Data Only
 *** FY '65 and '66 Aircraft Data Only

APPENDIX E

DETAILS OF REASON FOR REPAIR OR REPLACEMENT ANALYSIS OF UH-1/AH-1 MAINTAINABILITY AND RELIABILITY PROGRAM FIELD FAILURE/DISCREPANCY REPORT DATA

TABLE E-1. REASON FOR REPAIR OR REPLACEMENT/MTBR
ANALYSIS OF UH-1D/H M & R PROGRAM
MAIN ROTOR BLADE FAILURE REPORT DATA

Blade P/N 204-011-250-5	PORT HUCKER, ALABAMA				PORT HUCKER, ALABAMA				PORT HUCKER, ALABAMA				PORT HUCKER, ALABAMA				PORT HUCKER, ALABAMA			
	Number Repaired or Replaced	M-T-B Repaired or Replaced	Number Removed for Repair or Repl.	M-T-B Removed for Repair or Repl.	Number Replaced	M-T-B Replaced	Number Removed for Repair or Repl.	M-T-B Removed for Repair or Repl.	Number Repaired or Replaced	M-T-B Repaired or Replaced	Number Removed for Repair or Repl.	M-T-B Removed for Repair or Repl.	Number Repaired or Replaced	M-T-B Repaired or Replaced	Number Removed for Repair or Repl.	M-T-B Removed for Repair or Repl.	Number Repaired or Replaced	M-T-B Repaired or Replaced	Number Removed for Repair or Repl.	M-T-B Removed for Repair or Repl.
ALL CAUSES	1	1	0	0	0	0	0	0	100.0	100.0	0	0	0	0	0	0	0	0	0	0
I. PART CAUSES	1	1	0	0	0	0	0	0	100.0	100.0	0	0	0	0	0	0	0	0	0	0
A. <u>Excessive Vibration</u> Lateral vibration	1	1	0	0	0	0	0	0	100.0	100.0	0	0	0	0	0	0	0	0	0	0
B. <u>Deterioration</u>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C. <u>Ponding Failure</u> and separation at L-E strip	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tie cap separated Tie tab unthreaded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D. <u>Excessive heat</u> Sealer clipped at trim tab	1	1	0	0	0	0	0	0	100.0	100.0	0	0	0	0	0	0	0	0	0	0
II. EXTERNAL CAUSES	2	2	0	0	0	0	0	0	100.0	100.0	0	0	0	0	0	0	0	0	0	0
A. <u>Foreign Object Damage</u> Dent in lead edge Hit antenna Hit spent brass	2	2	0	0	0	0	0	0	100.0	100.0	0	0	0	0	0	0	0	0	0	0
B. <u>Overstressed</u> Hit trees Overstressed (or auto- rotated on)	2	2	0	0	0	0	0	0	100.0	100.0	0	0	0	0	0	0	0	0	0	0
C. <u>Heat Damage</u>	2	2	0	0	0	0	0	0	100.0	100.0	0	0	0	0	0	0	0	0	0	0
D. <u>Maintenance and Assembly Error</u>	2	2	0	0	0	0	0	0	100.0	100.0	0	0	0	0	0	0	0	0	0	0

TABLE E-II. REASON FOR REPAIR OR REPLACEMENT/MTOR ANALYSIS OF "H-1C M & R PROGRAM MAIN ROTOR BLADE FAILURE REPORT DATA

Blade P/W 540-011-001-005		PORT RICKER, ALABAMA Blade Time Base = 25,544 Flight Hours						VIETNAM Blade Time Base = 29,676 Flight Hours						
Reasons for Repair or Replacement	Number Repaired or Replaced	M-T-B Repairs or Replacement	Number Removed for Repair or Repl.	M-T-B Removals for Repair or Repl.	Number Replaced	M-T-B Replacements	Percent Repaired (Without Replacement)	Number Repaired or Replaced	M-T-B Repairs or Replacement	Number Removed for Repair or Repl.	M-T-B Removals for Repair or Repl.	Number Replaced	M-T-B Replacements	Percent Repaired (Without Replacement)
ALL CAUSES	23	1,111	18	1,419	17	1,503	26.1	46	645	41	724	41	724	10.9
I. PART CAUSES	13	1,965	11	2,322	10	2,554	23.1	5	2,968	5	2,968	5	2,968	0.0
A. <u>Excessive Vibration</u> Cannot track	2	2,838	2	2,838	2	2,838	0.0	2	7,419	2	7,419	2	7,419	0.0
B. <u>Deterioration</u>	0	--	0	--	0	--	--	0	--	0	--	0	--	--
C. <u>Engine Failure</u> Bond separation at L/E strip	2	12,772	2	12,772	1	12,772	50.0	1	29,676	1	29,676	1	29,676	0.0
D. <u>Engine Wear</u> Filter clogged at L/E	2	12,772	0	--	0	--	100.0	0	--	0	--	0	--	--
II. EXTERNAL CAUSES	10	2,554	7	3,649	7	3,649	30.0	41	724	36	824	36	824	13.3
A. <u>Foreign Object Damage</u> Bottle damage Cuts Dents Holes Scratches	2	12,772	1	25,544	1	25,544	50.0	20	989	25	1,197	25	1,197	15.7
	1	25,544	0	--	0	--	100.0	1	1,060	1	1,060	1	1,060	0.0
	1	25,544	1	25,544	1	25,544	0.0	1	29,676	1	29,676	1	29,676	0.0
B. <u>Overstress</u> Hit tree Hit unknown object Over-speed (engine) Over-speed (autorotation)	8	2,192	6	4,237	6	4,237	25.0	3	9,892	3	9,892	3	9,892	0.0
	1	25,544	1	25,544	1	25,544	0.0							0.0
	4	6,386	4	6,386	4	6,386	100.0							0.0
	2	12,772	0	--	0	--								
C. <u>Heat Damage</u>	0	--	0	--	0	--	--	0	--	0	--	0	--	--
D. <u>Maintenance & Engineering</u> Bad patch Bent by sling Crack at repair Maintenance error	0	--	0	--	0	--	--	0	3,710	0	3,710	0	3,710	0.0
									29,676		29,676		29,676	0.0
									7,419		7,419		7,419	0.0
									14,838		14,838		14,838	0.0

[illegible]

TABLE E-III (Cont'd)

Blade P/W 340-011-001-005	HUNTER ARMY AIR FIELD						VIETNAM					
	Blade Time Base - 30,964 Flight Hours						Blade Time Base - 101,456 Flight Hours					
Reasons for Repair or Replacement	Number Repaired or Replaced	M-T-B Repaired or Replacement	Number Removed for Repair or Repl.	M-T-B Removals for Repair or Repl.	Number Replaced	M-T-B Replacement	Number Replaced or Repl.	M-T-B Replaced or Repl.	Number Replaced or Repl.	M-T-B Replaced or Repl.	Number Replaced or Repl.	Percent Replaced or Repl.
II. EXTERNAL CAUSES (Cont'd)												
C. Heat Damage	2	--	2	--	2	--	2	--	2	--	2	--
D. Maintenance & Priming	1	30,964	1	30,964	1	30,964	1	30,964	1	30,964	1	30,964
Ead-patch												
Cracked at patched hole												
Hit tracking pole												
Maintenance damage												
Trim tab torn by sling												
E. Other	2	--	2	--	2	--	2	--	2	--	2	--
Hit by 90-degree gear box												
Hit by nose compartment cover												
III. NO FAILURE CAUSE	4	7,761	4	7,761	4	7,761	4	7,761	4	7,761	4	7,761
A. Time Change	4	7,761	4	7,761	4	7,761	4	7,761	4	7,761	4	7,761
Allowable operating time												
IV. UNKNOWN	2	15,482	2	15,482	2	15,482	2	15,482	2	15,482	2	15,482

APPENDIX F

DETAILS OF REASON FOR REMOVAL/MTR ANALYSIS OF BELL HELICOPTER COMPANY AND RED RIVER ARMY DEPOT MAIN ROTOR BLADE REPAIR AND SCRAP DATA

TABLE F-1. REASON FOR REMOVAL/MTR
ANALYSIS OF D/H MAIN ROTOR
BLADES REPAIRED OR SCRAPPED
AT BHC AND SCRAPPED AT RRAD

Blades From Aircraft Model(s): UH-1D/H

Part No. 204-011-250-005

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>2,820</u>	<u>428.3</u>	<u>100.00</u>
I. <u>PART CAUSES</u>	<u>464</u>	<u>450.8</u>	<u>16.45</u>
A. <u>Excessive Vibration</u>	<u>105</u>	<u>340.4</u>	<u>3.72</u>
Beyond specified tolerance	5	481.2	0.18
Cannot balance	64	339.2	2.27
Erratic	1	95.0	0.03
Excessive vibration	35	329.4	1.24
B. <u>Deterioration</u>	<u>102</u>	<u>449.7</u>	<u>3.62</u>
Cracked	83	447.5	2.94
Deteriorated	15	461.0	0.53
Loose rivets	2	556.5	0.07
Noisy	2	348.5	0.07
C. <u>Bonding Failure</u>	<u>155</u>	<u>457.2</u>	<u>5.50</u>
Bond separation	117	451.4	4.15
Delaminated	26	461.6	0.92
Lcose	10	531.4	0.35
Poor bonding	2	366.0	0.07
D. <u>Excessive Wear</u>	<u>78</u>	<u>537.6</u>	<u>2.77</u>
Erosion	60	530.1	2.13
Internal failure	7	588.0	0.25
Pitted	4	540.2	0.14
Worn excessively	7	550.1	0.25
E. <u>Corrosion</u>	<u>19</u>	<u>709.0</u>	<u>0.67</u>
Deposits	3	359.0	0.11
Leaking	1	530.0	0.03
Rust or corrosion	15	790.9	0.53
F. <u>Other</u>	<u>5</u>	<u>258.0</u>	<u>0.18</u>
Manufacturing defect	5	258.0	0.18
II. <u>EXTERNAL CAUSES</u>	<u>1,324</u>	<u>364.9</u>	<u>46.95</u>
A. <u>Foreign Object Damage</u>	<u>908</u>	<u>372.5</u>	<u>32.20</u>
Battle damage (combat damage)	218	430.6	7.73
Bent	7	373.9	0.25
Broken	6	442.3	0.21
Buckled	5	284.4	0.18
Collapsed	1	6.0	0.03
Damaged part, chip, nick, etc.	299	342.0	10.60
Dented	233	379.1	8.26

TABLE F-I (Cont'd)

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
II. EXTERNAL CAUSES			
A. <u>Foreign Object Damage (Cont'd)</u>			
Foreign object damage	81	321.9	2.87
Holes punched	58	361.7	2.06
Mutilated	0	--	0.00
B. <u>Overstressed</u>	390	345.1	13.83
Crash damage	136	395.4	4.82
Hard landing	6	410.5	0.21
Hit tree	1	620.0	0.03
Jammed	1	378.0	0.03
Overstressed	31	248.0	1.10
Overtorque	2	132.5	0.07
RPM out of limit	162	328.6	5.74
Sudden stoppage	49	310.1	1.74
Warped	2	493.0	0.07
C. <u>Heat Damage</u>	4	494.0	0.14
Blistered	1	765.0	0.03
Heat Damage	3	403.7	0.11
D. <u>Maintenance and Shipping Damage</u>	22	378.5	0.78
Bad patch, rivet, tab, etc.	18	383.6	0.64
Damaged in shipment	0	--	0.00
Improper handling	4	355.5	0.14
E. <u>Other</u>	0	--	0.00
III. NO FAILURE CAUSES	40	805.7	1.42
A. <u>Time Change</u>	8	2,064.6	0.28
Allowable operating time	8	2,064.6	0.28
B. <u>Other</u>	32	491.0	1.13
Inspect, evaluate, or repair	4	435.8	0.14
Lost or missing	8	350.2	0.28
No failure	16	558.4	0.57
Scheduled maintenance	4	557.8	0.14
IV. UNKNOWN CAUSES	992	487.3	35.18

TABLE F-II. REASON FOR REMOVAL/MTR
ANALYSIS OF C/G MAIN ROTOR
BLADES REPAIRED OR SCRAPPED
AT BHC AND SCRAPPED AT RRAD

Blades From Aircraft Model(s): UH-1C/AH-1G

Part No. 540-011-001-005

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>925</u>	<u>341.5</u>	<u>100.0</u>
I. <u>PART CAUSES</u>	<u>135</u>	<u>349.7</u>	<u>14.6</u>
A. <u>Excessive Vibration</u>	<u>74</u>	<u>323.4</u>	<u>8.0</u>
Beyond specified tolerance	2	715.5	0.2
Can't balance	45	328.2	4.9
Erratic	2	345.0	0.2
Excessive vibration	24	277.9	2.6
Mismatched	1	374.0	0.1
B. <u>Deterioration</u>	<u>28</u>	<u>321.2</u>	<u>3.0</u>
Cracked	21	396.2	2.3
Deteriorated	2	70.0	0.2
Loose rivets	1	276.0	0.1
Loose trim tabs	4	64.3	0.4
C. <u>Bonding Failure</u>	<u>21</u>	<u>351.9</u>	<u>2.3</u>
Bond separation	16	377.0	1.7
Delaminated	2	20.5	0.2
Loose	3	439.3	0.3
D. <u>Excessive Wear</u>	<u>6</u>	<u>647.2</u>	<u>0.7</u>
Erosion	3	746.0	0.3
Internal failure	1	504.0	0.1
Worn excessively	2	570.5	0.2
E. <u>Corrosion</u>	<u>6</u>	<u>502.0</u>	<u>0.7</u>
Rust or corrosion	6	502.0	0.7
F. <u>Other</u>	<u>0</u>	<u>-</u>	<u>0.0</u>
II. <u>EXTERNAL CAUSES</u>	<u>512</u>	<u>286.6</u>	<u>55.4</u>
A. <u>Foreign Object Damage</u>	<u>424</u>	<u>292.3</u>	<u>45.8</u>
Battle damage (combat damage)	236	294.1	25.5
Bent	3	319.3	0.3
Cut	1	395.0	0.1
Damaged part, chip, nick, etc.	77	307.4	8.3
Dented	33	270.9	3.6
Foreign object damage	26	261.6	2.8
Holes punched	47	291.7	5.1
Mutilated	1	36.0	0.1
B. <u>Overstressed</u>	<u>83</u>	<u>268.5</u>	<u>9.0</u>
Broken weights	1	599.0	0.1

TABLE F-II (Cont'd)

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
II. <u>EXTERNAL CAUSES</u>			
B. <u>Overstressed (Cont'd)</u>			
Crash damage	13	265.3	1.4
Hard landing	5	188.2	0.5
Hit tree	3	301.0	0.3
Overstressed	8	324.3	0.9
RPM out of limit	33	245.8	3.6
Sudden stoppage	20	284.5	2.2
C. <u>Heat Damage</u>	0	-	0.0
D. <u>Maintenance and Shipping Damage</u>	5	106.2	0.5
Damaged in shipment	0	-	0.0
Improper handling	5	106.2	0.5
E. <u>Other</u>	0	-	0.0
III. <u>NO FAILURE CAUSES</u>	57	811.6	6.2
A. <u>Time Change</u>	41	973.0	4.4
Allowable operating time	41	973.0	4.4
B. <u>Other</u>	16	397.9	1.7
No failure	15	406.0	1.6
Scheduled maintenance	1	277.0	0.1
IV. <u>UNKNOWN CAUSES</u>	221	342.3	23.9

TABLE F-III. REASON FOR REMOVAL/MTR ANALYSIS
OF D.H MAIN ROTOR BLADES REPAIRED
OR SCRAPPED AT BHC

Blades From Aircraft Model(s): UH-1D/H

Part No. 204-011-250-005

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>2,305</u>	<u>408.7</u>	<u>100.00</u>
I <u>PART CAUSES</u>	<u>459</u>	<u>445.1</u>	<u>19.91</u>
A. <u>Excessive Vibration</u>	<u>105</u>	<u>340.4</u>	<u>4.56</u>
Beyond specified tolerance	5	481.2	6.22
Cannot balance	64	339.2	2.78
Erratic	1	95.0	0.04
Excessive vibration	35	329.4	1.52
B. <u>Deterioration</u>	<u>102</u>	<u>449.7</u>	<u>4.43</u>
Cracked	83	447.5	3.60
Deteriorated	15	461.0	0.65
Loose rivets	2	556.5	0.09
Noisy	2	348.5	0.09
C. <u>Bonding Failure</u>	<u>153</u>	<u>453.1</u>	<u>6.64</u>
Bond separation	115	445.9	4.99
Delaminated	26	461.6	1.13
Loose	10	531.4	0.43
Poor bonding	2	366.0	0.09
D. <u>Excessive Wear</u>	<u>78</u>	<u>537.6</u>	<u>3.38</u>
Erosion	60	530.1	2.60
Internal failure	7	588.0	0.30
Pitted	4	540.2	0.17
Worn excessively	7	550.1	0.30
E. <u>Corrosion</u>	<u>16</u>	<u>634.4</u>	<u>0.69</u>
Deposits	3	359.0	0.13
Leaking	1	530.0	0.04
Rust or corrosion	12	712.0	0.52
F. <u>Other</u>	<u>5</u>	<u>258.0</u>	<u>0.22</u>
Manufacturing defect	5	258.0	0.22
II. <u>EXTERNAL CAUSES</u>	<u>979</u>	<u>343.4</u>	<u>42.47</u>
A. <u>Foreign Object Damage</u>	<u>697</u>	<u>350.4</u>	<u>30.24</u>
Battle damage (combat damage)	23	262.2	1.00
Bent	7	373.9	0.30
Broken	6	442.3	0.26
Buckled	5	284.4	0.22
Collapsed	1	6.0	0.04
Damaged part, chip, nick, etc.	297	341.2	12.89
Dented	233	379.1	10.11

TABLE F-III (Cont'd)

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
II. EXTERNAL CAUSES			
A. Foreign Object Damage (Cont'd)			
Foreign object damage	81	321.9	3.51
Holes punched	44	358.3	1.91
Mutilated	0	--	0.00
B. Overstressed	<u>256</u>	<u>319.1</u>	<u>11.11</u>
Crash damage	2	431.5	0.09
Hard landing	6	410.5	0.26
Hit tree	1	620.0	0.04
Jammed	1	378.0	0.04
Overstressed	31	248.0	1.34
Overtorque	2	132.5	0.09
RPM out of limit	162	328.6	7.03
Sudden stoppage	49	310.1	2.13
Warped	2	493.0	0.09
C. Heat Damage	<u>4</u>	<u>494.0</u>	<u>0.17</u>
Blistered	1	765.0	0.04
Heat Damage	3	403.7	0.13
D. Maintenance and Shipping Damage	<u>22</u>	<u>378.5</u>	<u>0.95</u>
Bad patch, rivet, mod, tab, etc.	18	383.6	0.78
Damaged in shipment	0	--	0.00
Improper handling	4	355.5	0.17
E. Other	<u>0</u>	<u>--</u>	<u>0.00</u>
III. NO FAILURE CAUSES	<u>33</u>	<u>509.4</u>	<u>1.43</u>
A. Time Change	<u>1</u>	<u>1,100.0</u>	<u>0.04</u>
Allowable operating time	1	1,100.0	0.04
B. Other	<u>32</u>	<u>421.0</u>	<u>1.39</u>
Inspect, evaluate, or repair	4	435.8	0.17
Lost or missing	8	350.2	0.35
No failure	16	558.4	0.69
Scheduled maintenance	4	557.8	0.17
IV. UNKNOWN CAUSES	<u>834</u>	<u>461.3</u>	<u>36.18</u>

TABLE F-IV. REASON FOR REMOVAL/MTR ANALYSIS
OF C/G M/R BLADES REPAIRED OR
SCRAPPED AT BHC

Blades From Aircraft Model(s): UH-1C/AH-1C

Part No. 540-011-001-5

Reason For Removal	Records With Part Time		Percent Of All Causes
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>606</u>	<u>309.4</u>	<u>100.0</u>
I. <u>PART CAUSES</u>	<u>124</u>	<u>335.0</u>	<u>20.5</u>
A. <u>Excessive Vibration</u>	<u>74</u>	<u>323.4</u>	<u>12.2</u>
Beyond specified tolerance	2	715.5	0.3
Can't balance	45	328.2	7.4
Erratic	2	345.0	0.3
Excessive vibration	24	277.9	4.0
Mismatched	1	374.0	0.2
B. <u>Deterioration</u>	<u>25</u>	<u>298.2</u>	<u>4.1</u>
Cracked	18	376.7	3.0
Deteriorated	2	70.0	0.3
Loose rivets	1	276.0	0.2
Loose trimtabs	4	64.3	0.7
C. <u>Bonding Failure</u>	<u>18</u>	<u>371.8</u>	<u>3.0</u>
Bond separation	13	410.2	2.1
Delaminated	2	20.5	0.3
Loose	3	439.3	0.5
D. <u>Excessive Wear</u>	<u>4</u>	<u>520.3</u>	<u>0.7</u>
Erosion	1	436.0	0.2
Internal failure	1	504.0	0.2
Worn excessively	2	570.5	0.3
E. <u>Corrosion</u>	<u>3</u>	<u>461.0</u>	<u>0.5</u>
Rust or corrosion	3	461.0	0.5
F. <u>Other</u>	<u>0</u>	<u>-</u>	<u>0.0</u>
II. <u>EXTERNAL CAUSES</u>	<u>305</u>	<u>273.8</u>	<u>50.3</u>
A. <u>Foreign Object Damage</u>	<u>229</u>	<u>281.4</u>	<u>37.8</u>
Battle damage (combat damage)	76	272.0	12.5
Bent	3	319.3	0.5
Cut	1	395.0	0.2
Damaged part, chip, nick, etc.	77	307.4	12.7
Dented	30	262.6	5.0
Foreign object damage	21	277.0	3.5
Holes punched	20	250.4	3.3
Mutilated	1	36.0	0.2
B. <u>Overstressed</u>	<u>71</u>	<u>261.4</u>	<u>11.7</u>
Broken weight.	1	599.0	0.2

TABLE P-IV (Cont'd)

Reason For Removal	Records With Part Time		Percent Of All Causes
	Number	MTR (Hours)	
II. <u>EXTERNAL CAUSES</u>			
B. <u>Overstressed (cont'd)</u>			
Crash damage	2	238.0	0.3
Hard landing	5	188.2	0.8
Hit tree	3	301.0	0.5
Overstressed	8	324.3	1.3
RPM out of limit	33	245.8	5.4
Sudden stoppage	19	259.9	3.1
C. <u>Heat Damage</u>	0	-	0.0
D. <u>Maintenance and Shipping Damage</u>	5	106.2	0.8
Damaged in shipment	0	-	0.0
Improper handling	5	106.2	0.8
E. <u>Other</u>	0	-	0.0
III. <u>NO FAILURE CAUSES</u>	29	693.7	4.8
A. <u>Time Change</u>	16	972.3	2.6
Allowable operating time	16	972.3	2.6
B. <u>Other</u>	13	350.8	2.1
No failure	12	357.0	2.0
Scheduled maintenance	1	277.0	0.2
IV. <u>UNKNOWN CAUSES</u>	148	286.1	24.4

TABLE F-V. REASON FOR REMOVAL MTR ANALYSIS
OF D H MAIN ROTOR BLADES REPAIRED
AT BHC

Blades From Aircraft Model(s): UH-1D, H

Part No. 204-011-251-005

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>934</u>	<u>310.9</u>	<u>100.0</u>
<u>I. PART CAUSES</u>	<u>161</u>	<u>308.8</u>	<u>12.2</u>
A. <u>Excessive Vibration</u>	<u>47</u>	<u>277.1</u>	<u>5.0</u>
Beyond specified tolerance	<u>1</u>	<u>516.0</u>	<u>0.1</u>
Cannot balance	<u>26</u>	<u>315.8</u>	<u>3.0</u>
Excessive vibration	<u>18</u>	<u>203</u>	<u>1.9</u>
B. <u>Deterioration</u>	<u>33</u>	<u>274.4</u>	<u>3.5</u>
Cracked	<u>27</u>	<u>266.3</u>	<u>2.9</u>
Deteriorated	<u>3</u>	<u>83.7</u>	<u>0.3</u>
Loose rivets	<u>2</u>	<u>556.5</u>	<u>0.2</u>
Noisy	<u>1</u>	<u>516.0</u>	<u>0.1</u>
C. <u>Bonding Failure</u>	<u>52</u>	<u>318.1</u>	<u>5.0</u>
Bond separation	<u>41</u>	<u>288.4</u>	<u>4.4</u>
Delaminated	<u>7</u>	<u>511.4</u>	<u>0.7</u>
Loose	<u>2</u>	<u>203.5</u>	<u>0.2</u>
Poor bonding	<u>2</u>	<u>366.0</u>	<u>0.2</u>
D. <u>Excessive Wear</u>	<u>25</u>	<u>387.0</u>	<u>2.7</u>
Erosion	<u>19</u>	<u>377.4</u>	<u>2.0</u>
Internal Failure	<u>2</u>	<u>456.5</u>	<u>0.2</u>
Pitted	<u>1</u>	<u>704.0</u>	<u>0.1</u>
Worn excessively	<u>3</u>	<u>296.0</u>	<u>0.3</u>
E. <u>Corrosion</u>	<u>3</u>	<u>395.7</u>	<u>0.3</u>
Deposits	<u>2</u>	<u>479.0</u>	<u>0.2</u>
Rust or corrosion	<u>1</u>	<u>279.0</u>	<u>0.1</u>
F. <u>Other</u>	<u>1</u>	<u>213.0</u>	<u>0.1</u>
Manufacturing defect	<u>1</u>	<u>213.0</u>	<u>0.1</u>
<u>II. EXTERNAL CAUSES</u>	<u>424</u>	<u>265.6</u>	<u>45.4</u>
A. <u>Foreign Object Damage</u>	<u>282</u>	<u>272.3</u>	<u>30.2</u>
Battle damage (combat damage)	<u>2</u>	<u>121.5</u>	<u>0.2</u>
Bent	<u>4</u>	<u>553.8</u>	<u>0.4</u>
Broken	<u>2</u>	<u>27.0</u>	<u>0.2</u>
Buckled	<u>1</u>	<u>6.0</u>	<u>0.1</u>
Damaged part, chip, nick, etc.	<u>134</u>	<u>277.5</u>	<u>14.3</u>
Dented	<u>100</u>	<u>288.9</u>	<u>10.7</u>
Foreign object damage	<u>28</u>	<u>189.7</u>	<u>3.0</u>
Holes punched	<u>11</u>	<u>260.9</u>	<u>1.2</u>

TABLE P-V (Cont'd)

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
II. EXTERNAL CAUSES (Cont'd)			
B. <u>Overstressed</u>	<u>131</u>	<u>246.6</u>	<u>14.0</u>
Crash damage	1	10.0	0.1
Hard landing	4	392.8	0.4
Overstressed	19	245.3	2.0
Overtorque	1	217.0	0.1
RPM out of limit	88	252.0	9.4
Sudden stoppage	18	204.0	1.9
C. <u>Heat Damage</u>	<u>2</u>	<u>518.0</u>	<u>0.2</u>
Blistered	1	765.0	0.1
Heat damage	1	271.0	0.1
D. <u>Maintenance and Shipping Damage</u>	<u>9</u>	<u>277.5</u>	<u>1.0</u>
Bad patch, rivet, tab, etc.	7	269.1	0.7
Improper handling	2	307.0	0.2
E. <u>Other</u>	<u>0</u>	<u>--</u>	<u>0.0</u>
III. NO FAILURE CAUSES	<u>9</u>	<u>421.4</u>	<u>1.0</u>
A. <u>Time Change</u>	<u>0</u>	<u>--</u>	<u>0.0</u>
B. <u>Other</u>	<u>9</u>	<u>421.4</u>	<u>1.0</u>
Inspect, evaluate, or repair	3	469.7	0.3
Lost or missing	6	397.3	0.6
IV. UNKNOWN CAUSES	<u>340</u>	<u>363.0</u>	<u>36.4</u>

TABLE F-VI. REASON FOR REMOVAL/MTR ANALYSIS
OF C/G MAIN ROTOR BLADES
REPAIRED AT BHC

Blades From Aircraft Model(s): UH-1C, AH-1G

Part No. 540-011-001-005

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>297</u>	<u>241.4</u>	<u>100.0</u>
I. <u>PART CAUSES</u>	<u>74</u>	<u>241.7</u>	<u>24.9</u>
A. <u>Excessive Vibration</u>	<u>50</u>	<u>240.6</u>	<u>16.8</u>
Beyond specified tolerance	1	515.0	0.3
Can't balance	28	213.9	9.4
Erratic	1	223.0	0.3
Excessive vibration	19	259.5	6.4
Mismatched	1	374.0	0.3
B. <u>Deterioration</u>	<u>14</u>	<u>195.9</u>	<u>4.7</u>
Cracked	7	295.7	2.4
Deteriorated	2	70.0	0.7
Loose rivets	1	276.0	0.3
Loose trimtabs	4	64.3	1.3
C. <u>Bonding Failure</u>	<u>7</u>	<u>209.8</u>	<u>2.4</u>
Bond separation	6	241.8	2.0
Delaminated	1	18.0	0.3
D. <u>Excessive Wear</u>	<u>3</u>	<u>548.3</u>	<u>1.0</u>
Internal failure	1	504.0	0.3
Worn excessively	2	570.5	0.7
E. <u>Corrosion</u>	<u>0</u>	<u>-</u>	<u>0.0</u>
F. <u>Other</u>	<u>0</u>	<u>-</u>	<u>0.0</u>
II. <u>EXTERNAL CAUSES</u>	<u>123</u>	<u>235.6</u>	<u>41.4</u>
A. <u>Foreign Object Damage</u>	<u>68</u>	<u>251.5</u>	<u>22.9</u>
Battle damage (combat damage)	9	101.1	3.0
Cut	1	395.0	0.3
Damaged part, chip, nick, etc.	30	301.2	10.1
Dented	13	208.5	4.4
Foreign object damage	10	302.6	3.4
Holes punched	5	205.0	1.7
B. <u>Overstressed</u>	<u>51</u>	<u>230.5</u>	<u>17.2</u>
Broken weights	1	599.0	0.3
Crash damage	1	344.0	0.3
Hard landing	1	6.0	0.3
Hit tree	1	230.0	0.3
Overstressed	5	342.5	1.7
RPM out of limit	30	238.5	10.1
Sudden stoppage	12	142.5	4.0

TABLE P-VI (Cont'd)

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	(Hours)	
II. <u>EXTERNAL CAUSES (Cont'd)</u>			
G. <u>Heat Damage</u>	<u>0</u>	<u>-</u>	<u>0.0</u>
D. <u>Maintenance and Shipping Damage</u>	<u>4</u>	<u>29.0</u>	<u>1.3</u>
<u>Damaged in shipment</u>	<u>0</u>	<u>-</u>	<u>0.0</u>
<u>Improper handling</u>	<u>4</u>	<u>29.0</u>	<u>1.3</u>
E. <u>Other</u>	<u>0</u>	<u>-</u>	<u>0.0</u>
III. <u>NO FAILURE CAUSES</u>	<u>10</u>	<u>306.6</u>	<u>3.4</u>
A. <u>Time Change</u>	<u>0</u>	<u>-</u>	<u>0.0</u>
B. <u>Other</u>	<u>10</u>	<u>306.6</u>	<u>3.4</u>
<u>No Failure</u>	<u>10</u>	<u>306.6</u>	<u>3.4</u>
IV. <u>UNKNOWN CAUSES</u>	<u>90</u>	<u>242.0</u>	<u>30.3</u>

TABLE F-VII. REASON FOR REMOVAL MTR ANALYSIS
OF D. H. MAIN ROTOR BLADES
SCRAPPED AT BHC AND BRAD

Blades From Aircraft Model(s): UH-1D II

Part No. 701-011 750-001

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>1,886</u>	<u>186.7</u>	<u>100.00</u>
I. <u>PART CAUSES</u>	<u>303</u>	<u>526.2</u>	<u>28.27</u>
A. <u>Excessive Vibration</u>	<u>56</u>	<u>392.4</u>	<u>21.08</u>
Beyond specified tolerance	4	372.5	0.21
Cannot balance	36	257.4	1.41
Erratic	1	95.0	0.05
Excessive vibration	17	462.4	0.95
B. <u>Deterioration</u>	<u>69</u>	<u>533.2</u>	<u>2.86</u>
Cracked	56	534.9	2.97
Deteriorated	12	555.3	0.64
Noisy	1	181.0	0.05
C. <u>Bonding Failure</u>	<u>103</u>	<u>527.4</u>	<u>2.86</u>
Bond separation	76	549.5	2.93
Delaminated	19	643.3	1.01
Loose	8	613.4	0.32
D. <u>Excessive Wear</u>	<u>53</u>	<u>608.6</u>	<u>3.28</u>
Erosion	41	600.8	2.77
Internal Failure	5	640.6	0.37
Pitted	3	485.6	0.16
Worn excessively	4	740.5	0.21
E. <u>Corrosion</u>	<u>16</u>	<u>767.7</u>	<u>4.12</u>
Deposits	1	119.0	0.03
Leaking	1	530.0	0.05
Rust or corrosion	14	831.0	0.74
F. <u>Other</u>	<u>4</u>	<u>269.2</u>	<u>0.14</u>
Manufacturing defect	4	269.2	0.14
II. <u>EXTERNAL CAUSES</u>	<u>900</u>	<u>411.6</u>	<u>22.22</u>
A. <u>Foreign Object Damage</u>	<u>626</u>	<u>417.6</u>	<u>22.49</u>
Battle damage (combat damage)	216	433.5	2.43
Bent	3	134.0	0.16
Broken	4	650.0	0.21
Buckled	4	354.0	0.21
Collapsed	1	6.0	0.05
Damaged part, chip, nick, etc.	165	394.4	2.75
Dented	133	446.9	7.05
Foreign object damage	53	391.7	2.61
Holes punched	47	385.3	2.49

TABLE F-VII (Cont'd)

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
II. <u>EXTERNAL CAUSES</u> (Cont'd)			
B. <u>Overstressed</u>	<u>259</u>	<u>394.9</u>	<u>13.73</u>
Crash damage	135	398.3	7.16
Hard landing	2	446.0	0.11
Hit tree	1	620.0	0.05
Jammed	1	378.0	0.05
Overstressed	12	252.3	0.64
Overtorque	1	48.0	0.05
RPM out of limit	74	419.6	3.92
Sudden stoppage	31	371.7	1.64
Warped	2	493.0	0.11
C. <u>Heat Damage</u>	<u>2</u>	<u>470.0</u>	<u>0.11</u>
Heat damage	2	470.0	0.11
D. <u>Maintenance and Shipping Damage</u>	<u>13</u>	<u>448.4</u>	<u>0.69</u>
Bad patch, rivet, tab, etc.	11	456.5	0.58
Improper handling	2	404.0	0.11
E. <u>Other</u>	<u>0</u>	<u>--</u>	<u>0.00</u>
III. <u>NO FAILURE CAUSES</u>	<u>31</u>	<u>917.3</u>	<u>1.64</u>
A. <u>Time Change</u>	<u>8</u>	<u>2,064.6</u>	<u>0.42</u>
Allowable operating time	8	2,064.6	0.42
B. <u>Other</u>	<u>23</u>	<u>518.2</u>	<u>1.22</u>
Inspect, evaluate, or repair	1	334.0	0.05
Lost or missing	2	209.0	0.11
No failure	16	558.4	0.85
Scheduled maintenance	4	557.8	0.21
IV. <u>UNKNOWN CAUSES</u>	<u>652</u>	<u>552.1</u>	<u>34.57</u>

TABLE F-VIII. REASON FOR REMOVAL/MTR ANALYSIS
OF C/G MAIN ROTOR BLADES
SCRAPPED AT BHC AND RRAD

Blades From Aircraft Model(s): UH-1C, AH-1G Part No. 540-011-001-005

Reason For Removal	Records With Part Time		Percent Of All Causes
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>628</u>	<u>388.7</u>	<u>100.0</u>
I. <u>PART CAUSES</u>	<u>61</u>	<u>480.7</u>	<u>9.7</u>
A. <u>Excessive Vibration</u>	<u>24</u>	<u>495.9</u>	<u>3.8</u>
Beyond specified tolerance	1	916.0	0.2
Can't balance	17	516.5	2.7
Erratic	1	467.0	0.2
Excessive vibration	5	347.8	0.8
B. <u>Deterioration</u>	<u>14</u>	<u>446.4</u>	<u>2.2</u>
Cracked	14	446.4	2.2
C. <u>Bonding Failure</u>	<u>14</u>	<u>423.0</u>	<u>2.2</u>
Bond separation	10	458.1	1.6
Delaminated	1	23.0	0.2
Loose	3	439.3	0.5
D. <u>Excessive Wear</u>	<u>3</u>	<u>746.0</u>	<u>0.5</u>
Erosion	3	746.0	0.5
E. <u>Corrosion</u>	<u>6</u>	<u>502.0</u>	<u>1.0</u>
Rust or corrosion	6	502.0	1.0
F. <u>Other</u>	<u>0</u>	<u>-</u>	<u>0.0</u>
II. <u>EXTERNAL CAUSES</u>	<u>389</u>	<u>302.7</u>	<u>61.9</u>
A. <u>Foreign Object Damage</u>	<u>356</u>	<u>300.0</u>	<u>56.7</u>
Battle damage (combat damage)	227	301.7	36.1
Bent	3	319.3	0.5
Damaged part, chip, nick, etc.	47	311.3	7.5
Dented	20	311.4	3.2
Foreign object damage	16	236.0	2.5
Holes punched	42	302.0	6.7
Mutilated	1	36.0	0.2
B. <u>Overstressed</u>	<u>32</u>	<u>329.2</u>	<u>5.1</u>
Crash damage	12	258.7	1.9
Hard landing	4	233.8	0.6
Hit tree	2	336.5	0.3
Overstressed	3	294.0	0.5
RPM out of limit	3	319.3	0.5
Sudden stoppage	8	497.6	1.3
C. <u>Heat Damage</u>	<u>0</u>	<u>-</u>	<u>0.0</u>

TABLE F-VIII (Cont'd)

Reason For Removal	Records With Part Time		Percent Of All Causes
	Number	MTR (Hours)	
II. <u>EXTERNAL CAUSES</u>			
D. <u>Maintenance and Shipping Damage</u>	1	415.0	0.2
<u>Improper handling</u>	1	415.0	0.2
E. <u>Other</u>	0	-	0.0
III. <u>NO FAILURE CAUSES</u>	47	919.0	7.5
A. <u>Time change</u>	41	973.0	6.5
<u>Allowable operating time</u>	41	973.0	6.5
B. <u>Other</u>	6	550.2	1.0
<u>No failure</u>	5	604.8	0.8
<u>Scheduled maintenance</u>	1	277.0	0.2
IV. <u>UNKNOWN CAUSES</u>	131	411.2	20.9

TABLE IX. REASON FOR REMOVAL/MIR ANALYSIS
OF D-H MAIN ROTOR BLADES
SCRAPPED AT BHC

Blades From Aircraft Model(s): UH-1D/H

Part No. 204 011-250-005

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MIR (Hours)	
<u>ALL CAUSES</u>	<u>1,371</u>	<u>476.0</u>	<u>100.00</u>
<u>I. PART CAUSES</u>	<u>298</u>	<u>518.8</u>	<u>21.74</u>
A. <u>Excessive Vibration</u>	<u>58</u>	<u>391.6</u>	<u>4.23</u>
Beyond specified tolerance	4	472.5	0.26
Cannot balance	36	357.4	2.63
Erratic	1	95.0	0.07
Excessive vibration	17	462.4	1.24
B. <u>Deterioration</u>	<u>69</u>	<u>533.3</u>	<u>5.03</u>
Cracked	56	534.9	4.08
Deteriorated	12	555.3	0.88
Noisy	1	181.0	0.07
C. <u>Bonding Failure</u>	<u>101</u>	<u>522.6</u>	<u>1.37</u>
Bond separation	74	523.2	5.40
Delaminated	19	443.3	1.39
Loose	8	613.4	0.58
D. <u>Excessive Wear</u>	<u>53</u>	<u>608.6</u>	<u>3.87</u>
Erosion	41	600.8	2.99
Internal failure	5	640.6	0.36
Pitted	3	485.6	0.22
Worn excessively	4	740.5	0.29
E. <u>Corrosion</u>	<u>13</u>	<u>689.5</u>	<u>0.95</u>
Deposits	1	119.0	0.07
Leaking	1	530.0	0.07
Rust or corrosion	11	755.9	0.80
F. <u>Other</u>	<u>4</u>	<u>269.2</u>	<u>0.29</u>
Manufacturing defect	4	269.2	0.29
<u>II. EXTERNAL CAUSES</u>	<u>555</u>	<u>402.9</u>	<u>40.48</u>
A. <u>Foreign Object Damage</u>	<u>415</u>	<u>403.5</u>	<u>30.27</u>
Battle damage (combat damage)	21	275.6	1.53
Bent	3	134.0	0.22
Broken	4	650.0	0.29
Buckled	4	354.0	0.29
Collapsed	1	6.0	0.07
Damaged part, chip, nick, etc.	163	393.6	11.89
Dented	133	446.9	9.70
Foreign object damage	53	391.7	3.87
Holes punched	33	390.8	2.41
Mutilated	0	--	0.00

TABLE P-IX (Cont'd)

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
II. <u>EXTERNAL CAUSES</u> (Cont'd)			
B. <u>Overstressed</u>	125	395.0	9.12
Crash damage	1	853.0	0.07
Hard landing	2	446.0	0.15
Hit tree	1	620.0	0.07
Jammed	1	378.0	0.07
Overstressed	12	252.3	0.89
Overtorque	1	48.0	0.07
RPM out of limit	74	419.6	5.40
Sudden stoppage	31	371.7	2.26
Warped	2	493.0	0.15
C. <u>Heat Damage</u>	2	470.0	0.15
Heat Damage	2	470.0	0.15
D. <u>Maintenance and Shipping Damage</u>	13	448.4	0.95
Bad patch, rivet, mod, tab, etc.	11	456.5	0.80
Damaged in shipment	0	--	0.00
Improper handling	2	404.0	0.15
E. <u>Other</u>	0	--	0.00
III. <u>NO FAILURE CAUSES</u>	24	542.4	1.75
A. <u>Time Change</u>	1	1,100.0	0.07
Allowable operating time	1	1,100.0	0.07
B. <u>Other</u>	23	518.2	1.68
Inspect, evaluate, or repair	1	334.0	0.07
Lost or missing	2	209.0	0.15
No failure	16	558.4	1.17
Scheduled maintenance	4	557.8	0.29
IV. <u>UNKNOWN CAUSES</u>	494	529.0	36.03

TABLE F-X. REASON FOR REMOVAL/MTR ANALYSIS
OF C/G MAIN ROTOR BLADES
SCRAPPED AT BHC

Blades From Aircraft Model(s): UH-1C/AH-1G

Part No. 540-011-001-005

Reason For Removal	Records With Part Time		Percent Of All Causes
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>309</u>	<u>374.9</u>	<u>100.0</u>
<u>I. PART CAUSES</u>	<u>50</u>	<u>473.1</u>	<u>16.2</u>
A. <u>Excessive Vibration</u>	<u>24</u>	<u>495.9</u>	<u>7.8</u>
Beyond specified tolerance	1	916.0	0.3
Can't balance	17	516.5	5.5
Erratic	1	467.0	0.3
Excessive vibration	5	347.8	1.6
B. <u>Deterioration</u>	<u>11</u>	<u>428.3</u>	<u>3.6</u>
Cracked	11	428.3	3.6
C. <u>Bonding Failure</u>	<u>11</u>	<u>474.8</u>	<u>3.6</u>
Bond separation	7	554.5	2.3
Delamination	1	23.0	0.3
Loose	3	439.3	1.0
D. <u>Excessive Wear</u>	<u>1</u>	<u>436.0</u>	<u>0.3</u>
Erosion	1	436.0	0.3
E. <u>Corrosion</u>	<u>3</u>	<u>461.0</u>	<u>1.0</u>
Rust or corrosion	3	461.0	1.0
F. <u>Other</u>	<u>0</u>	<u>-</u>	<u>0.0</u>
<u>II. EXTERNAL CAUSES</u>	<u>182</u>	<u>299.8</u>	<u>58.9</u>
A. <u>Foreign Object Damage</u>	<u>161</u>	<u>294.0</u>	<u>52.1</u>
Battle damage (combat damage)	67	295.0	21.7
Bent	3	319.3	1.0
Damaged part, chip, nick, etc.	47	311.3	15.2
Dented	17	303.9	5.5
Foreign object damage	11	253.7	3.6
Holes punched	15	265.5	4.9
Mutilated	1	36.0	0.3
B. <u>Overstressed</u>	<u>20</u>	<u>340.4</u>	<u>6.5</u>
Crash damage	1	132.0	0.3
Hard landing	4	233.8	1.3
Hit tree	2	336.5	0.7
Overstressed	3	294.0	1.0
RPM out of limit	3	319.3	1.0
Sudden stoppage	7	461.2	2.3
C. <u>Heat Damage</u>	<u>0</u>	<u>-</u>	<u>0.0</u>

TABLE F-X (Cont'd)

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MFR (Hours)	
II. <u>EXTERNAL CAUSES</u> (Cont'd)			
D. <u>Maintenance and Shipping Damage</u>	<u>1</u>	<u>415.0</u>	<u>0.3</u>
Improper handling	1	415.0	0.3
E. <u>Other</u>	<u>0</u>	<u>-</u>	<u>0.0</u>
0	0	-	0.0
III. <u>NO FAILURE CAUSES</u>	<u>19</u>	<u>897.5</u>	<u>6.1</u>
A. <u>Time Change</u>	<u>16</u>	<u>972.3</u>	<u>5.2</u>
Allowable operating time	16	972.3	5.2
B. <u>Other</u>	<u>3</u>	<u>498.3</u>	<u>1.0</u>
No failure	2	609.0	0.7
Scheduled maintenance	1	277.0	0.3
IV. <u>UNKNOWN CAUSES</u>	<u>58</u>	<u>354.5</u>	<u>18.8</u>
58	354.5	18.8	

TABLE P-XI. REASON FOR REMOVAL MIR ANALYSIS
OF D/H MAIN ROTOR BLADES
SCRAPPED AT RRAD

Blades From Aircraft Model(s): UH-1D/H

Part No. 204-011 250-005

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MIR (Hours)	
<u>ALL CAUSES</u>	<u>515</u>	<u>516.2</u>	<u>100.0</u>
I. <u>PART CAUSES</u>	<u>5</u>	<u>971.6</u>	<u>1.0</u>
A. <u>Excessive Vibration</u>	<u>0</u>	<u>--</u>	<u>0.0</u>
B. <u>Deterioration</u>	<u>0</u>	<u>--</u>	<u>0.0</u>
C. <u>Bonding Failure</u>	<u>2</u>	<u>769.5</u>	<u>0.4</u>
<u>Bond separation</u>	<u>2</u>	<u>769.5</u>	<u>0.4</u>
D. <u>Excessive Wear</u>	<u>0</u>	<u>--</u>	<u>0.0</u>
E. <u>Corrosion</u>	<u>3</u>	<u>1,106.3</u>	<u>0.6</u>
<u>Rust or corrosion</u>	<u>3</u>	<u>1,106.3</u>	<u>0.6</u>
F. <u>Other</u>	<u>0</u>	<u>--</u>	<u>0.0</u>
II. <u>EXTERNAL CAUSES</u>	<u>345</u>	<u>425.8</u>	<u>62.0</u>
A. <u>Foreign Object Damage</u>	<u>211</u>	<u>445.4</u>	<u>41.0</u>
<u>Battle damage (combat damage)</u>	<u>195</u>	<u>450.5</u>	<u>37.9</u>
<u>Damaged part, chip, nick, etc.</u>	<u>2</u>	<u>463.0</u>	<u>0.4</u>
<u>Holes punched</u>	<u>14</u>	<u>372.4</u>	<u>2.7</u>
B. <u>Overstressed</u>	<u>134</u>	<u>394.9</u>	<u>26.0</u>
<u>Crash damage</u>	<u>134</u>	<u>394.9</u>	<u>26.0</u>
C. <u>Heat Damage</u>	<u>0</u>	<u>--</u>	<u>0.0</u>
D. <u>Maintenance and Shipping Damage</u>	<u>0</u>	<u>--</u>	<u>0.0</u>
E. <u>Other</u>	<u>0</u>	<u>--</u>	<u>0.0</u>
III. <u>NO FAILURE CAUSES</u>	<u>7</u>	<u>2,202.4</u>	<u>1.4</u>
A. <u>Time Change</u>	<u>7</u>	<u>2,202.4</u>	<u>1.4</u>
<u>Allowable operating time</u>	<u>7</u>	<u>2,202.4</u>	<u>1.4</u>
B. <u>Other</u>	<u>0</u>	<u>--</u>	<u>0.0</u>
IV. <u>UNKNOWN CAUSES</u>	<u>158</u>	<u>624.4</u>	<u>30.7</u>

TABLE F-XII. REASON FOR REMOVAL/MTR ANALYSIS
OF C/G MAIN ROTOR BLADES
SCRAPPED AT RRAD

Blades From Aircraft Model(s): UH-1G/AH-1G

Part No. 540-011-001-005

Reason For Removal	Records With Part Time		Percent of All Causes
	Number	MTR (Hours)	
<u>ALL CAUSES</u>	<u>319</u>	<u>402.2</u>	<u>100.0</u>
I. <u>PART CAUSES</u>	<u>11</u>	<u>515.3</u>	<u>3.4</u>
A. <u>Excessive Vibration</u>	<u>0</u>	<u>-</u>	<u>0.0</u>
B. <u>Deterioration</u>	<u>3</u>	<u>512.6</u>	<u>0.9</u>
<u>Cracked</u>	<u>3</u>	<u>512.6</u>	<u>0.9</u>
C. <u>Bonding Failure</u>	<u>3</u>	<u>233.3</u>	<u>0.9</u>
<u>Bond separation</u>	<u>3</u>	<u>233.3</u>	<u>0.9</u>
D. <u>Excessive Wear</u>	<u>2</u>	<u>901.0</u>	<u>0.6</u>
<u>Erosion</u>	<u>2</u>	<u>901.0</u>	<u>0.6</u>
E. <u>Corrosion</u>	<u>3</u>	<u>543.0</u>	<u>0.9</u>
<u>Rust or corrosion</u>	<u>3</u>	<u>543.0</u>	<u>0.9</u>
F. <u>Other</u>	<u>0</u>	<u>-</u>	<u>0.0</u>
II. <u>EXTERNAL CAUSES</u>	<u>207</u>	<u>305.3</u>	<u>64.9</u>
A. <u>Foreign Object Damage</u>	<u>195</u>	<u>305.0</u>	<u>61.1</u>
<u>Battle damage (combat damage)</u>	<u>160</u>	<u>304.5</u>	<u>50.2</u>
<u>Dented</u>	<u>3</u>	<u>354.0</u>	<u>0.9</u>
<u>Foreign object damage</u>	<u>5</u>	<u>197.0</u>	<u>1.6</u>
<u>Holes punched</u>	<u>27</u>	<u>322.3</u>	<u>8.5</u>
B. <u>Overstressed</u>	<u>12</u>	<u>310.4</u>	<u>3.8</u>
<u>Crash damage</u>	<u>11</u>	<u>270.2</u>	<u>3.4</u>
<u>Sudden stoppage</u>	<u>1</u>	<u>752.0</u>	<u>0.3</u>
C. <u>Heat Damage</u>	<u>0</u>	<u>-</u>	<u>0.0</u>
D. <u>Maintenance and Shipping Damage</u>	<u>0</u>	<u>-</u>	<u>0.0</u>
E. <u>Other</u>	<u>0</u>	<u>-</u>	<u>0.0</u>
III. <u>NO FAILURE CAUSES</u>	<u>26</u>	<u>933.6</u>	<u>8.8</u>
A. <u>Time Change</u>	<u>25</u>	<u>973.4</u>	<u>7.8</u>
<u>Allowable operating time</u>	<u>25</u>	<u>973.4</u>	<u>7.8</u>
B. <u>Other</u>	<u>3</u>	<u>602.0</u>	<u>0.9</u>
<u>No failure</u>	<u>3</u>	<u>602.0</u>	<u>0.9</u>
IV. <u>UNKNOWN CAUSES</u>	<u>73</u>	<u>456.2</u>	<u>22.9</u>

APPENDIX G

DETAILS OF REASON FOR SCRAPPAGE ANALYSIS OF BELL HELICOPTER COMPANY MAIN ROTOR BLADE SCRAP DATA

**TABLE G-1. REASON FOR SCRAPPAGE OF D/H MAIN ROTOR
BLADES PROCESSED BY BHC AND RRAD**

Model UH-1D/H

Dwg./Part No. 204-011-250-005

REASON FOR SCRAPPAGE	No. of Blades Scrapped		
	RRAD	BHC	Total
<u>ALL CAUSES</u>	<u>1453</u>	<u>1420</u>	<u>2873</u>
I. <u>PART CAUSES</u>	<u>208</u>	<u>1042</u>	<u>1250</u>
A. <u>Imbalance</u>	<u>0</u>	<u>13</u>	<u>13</u>
Pushing out of alignment		1	1
Can't balance		1	1
Tip or edge heavy		3	3
Beyond specified tolerance		8	8
B. <u>Deterioration</u>	<u>2</u>	<u>35</u>	<u>37</u>
Cracked		34	34
Rough	2	1	3
C. <u>Bonding Failure</u>	<u>15</u>	<u>81</u>	<u>96</u>
Bonding failure		2	2
Core separation		1	1
Delaminated		1	1
Separated	10	39	49
Void	5	38	43
D. <u>Corrosion</u>	<u>191</u>	<u>287</u>	<u>478</u>
Corroded	191	287	478
E. <u>Water Contamination</u>	<u>0</u>	<u>626</u>	<u>626</u>
Water in blade		626	626
II. <u>EXTERNAL CAUSES</u>	<u>1227</u>	<u>343</u>	<u>1570</u>
A. <u>Foreign Object Damage</u>	<u>959</u>	<u>203</u>	<u>1162</u>
Bullet holes	483	42	525
Creased		1	1
Cut	5	19	24
Damaged	7	7	14
Dent		17	17
Foreign object damage	1	5	6
Holes	462	81	543
Scored		5	5
Torn	1	26	27
B. <u>Overstressed</u>	<u>268</u>	<u>140</u>	<u>408</u>
Bent		13	13
Bowed		12	12
Broken		3	3
Buckled		7	7
Crash damage	254		254
Crushed core		8	8

TABLE G-1 (Cont'd)

REASON FOR SCRAPPAGE	No. of Blades Scrapped		
	RRAD	BHC	Total
II. <u>EXTERNAL CAUSES</u>			
B. <u>Overstressed</u> (Cont'd)			
Distorted	14	71	85
Mutilated		21	21
Warped		5	5
III. <u>NO FAILURE CAUSES</u>	<u>11</u>	<u>4</u>	<u>15</u>
A. <u>Time Change</u>	<u>11</u>	<u>4</u>	<u>15</u>
Allowable operating time	11	4	15
IV. <u>OTHER CAUSES</u>	<u>7</u>	<u>31</u>	<u>38</u>
A. <u>Unknown</u>	<u>7</u>	<u>31</u>	<u>38</u>

TABLE G-II. REASON FOR SCRAPPAGE OF C/O MAIN ROTOR
BLADES PROCESSED BY BHC AND RRAD

Model: UH-1C/AH-1G

Dwg./Part No. 540-011-001-005

REASON FOR SCRAPPAGE	No. of Blades Scrapped		
	RRAD	BHC	Total
<u>ALL CAUSES</u>	<u>634</u>	<u>341</u>	<u>975</u>
I. <u>PART CAUSES</u>	<u>18</u>	<u>102</u>	<u>120</u>
A. <u>Imbalance</u>	<u>0</u>	<u>3</u>	<u>3</u>
Weights loose		<u>3</u>	<u>3</u>
B. <u>Deterioration</u>	<u>0</u>	<u>22</u>	<u>22</u>
Cracked		<u>16</u>	<u>16</u>
Worn		<u>6</u>	<u>6</u>
C. <u>Bonding Failure</u>	<u>6</u>	<u>6</u>	<u>12</u>
Separated	<u>6</u>	<u>1</u>	<u>7</u>
Void		<u>5</u>	<u>5</u>
D. <u>Corrosion</u>	<u>12</u>	<u>50</u>	<u>62</u>
Corroded	<u>12</u>	<u>50</u>	<u>62</u>
E. <u>Water Contamination</u>	<u>0</u>	<u>21</u>	<u>21</u>
Water in blade		<u>21</u>	<u>21</u>
II. <u>EXTERNAL CAUSES</u>	<u>560</u>	<u>194</u>	<u>754</u>
A. <u>Foreign Object Damage</u>	<u>536</u>	<u>157</u>	<u>693</u>
Bullet holes	<u>353</u>	<u>53</u>	<u>406</u>
Creased		<u>2</u>	<u>2</u>
Cut	<u>2</u>	<u>18</u>	<u>20</u>
Damaged	<u>1</u>	<u>3</u>	<u>4</u>
Dent		<u>13</u>	<u>13</u>
Foreign object damage		<u>1</u>	<u>1</u>
Holes	<u>180</u>	<u>55</u>	<u>235</u>
Scored		<u>1</u>	<u>1</u>
Torn		<u>11</u>	<u>11</u>
B. <u>Overstressed</u>	<u>24</u>	<u>37</u>	<u>61</u>
Bent		<u>4</u>	<u>4</u>
Broken		<u>3</u>	<u>3</u>
Crash damage	<u>22</u>		<u>22</u>
Crushed core		<u>1</u>	<u>1</u>
Distorted	<u>2</u>	<u>14</u>	<u>16</u>
Mutilated		<u>15</u>	<u>15</u>
III. <u>NO FAILURE CAUSES</u>	<u>53</u>	<u>20</u>	<u>73</u>
A. <u>Time Change</u>	<u>53</u>	<u>20</u>	<u>73</u>
Allowable operating time	<u>53</u>	<u>20</u>	<u>73</u>

TABLE G-II (Cont'd)

REASON FOR SCRAPPAGE	<u>No. of Blades Scrapped</u>		
	RRAD	BHC	Total
<u>ALL CAUSES</u> (Cont'd)			
IV. <u>OTHER CAUSES</u>	<u>3</u>	<u>25</u>	<u>28</u>
A. <u>Unknown</u>	<u>3</u>	<u>25</u>	<u>28</u>

TABLE G-III. REASON FOR REMOVAL VS. REASON
FOR SCRAPPAGE OF D/H MAIN ROTOR
BLADES PROCESSED BY BHC

Blades from Aircraft Model(s): UH-1D/H Part No.: 200-600-250-5

REASON FOR REMOVAL	REASON FOR SCRAPPAGE											
	I. PART CAUSES			II. EXTERNAL CAUSES			TOTAL					
	A. Imbalance	B. Deterioration	C. Bonding failure	D. Corrosion	E. Water contamination	F. Foreign object damage	ALL CAUSES	I. PART CAUSES	II. EXTERNAL CAUSES	TOTAL	PERCENT	PERCENT
ALL CAUSES	1420	1042	13	35	81	287	626	343	203	140	18	36
I. PART CAUSES	291	250	2	7	18	92	131	38	22	15	2	3
A. Excessive vibration beyond specified tolerance	57	50	2	2	3	20	33	7	1	3	1	1
Can't balance	35	32	1	1	1	6	20	3	1	2	1	1
Erratic	1	0	1	1	1	1	13	1	1	1	1	1
Excessive vibration	17	15	1	1	1	1	25	3	1	1	1	1
B. Deterioration	68	53	1	3	3	25	23	3	1	1	1	1
Cracked	54	42	1	1	1	6	23	3	1	1	1	1
Deteriorated	13	10	1	1	1	1	16	1	1	1	1	1
Noisy	1	1	1	1	1	1	5	1	1	1	1	1
C. Bonding failure	100	92	1	1	1	33	50	1	1	1	1	1
Bond separation	73	68	1	1	1	27	36	1	1	1	1	1
Delaminated	19	16	1	1	1	3	20	1	1	1	1	1
Loose	8	8	1	1	1	3	13	1	1	1	1	1
D. Excessive wear	50	40	1	1	1	15	20	1	1	1	1	1
Erosion	39	30	1	1	1	13	23	1	1	1	1	1
Internal failure	5	4	1	1	1	1	7	1	1	1	1	1
Pitted	3	3	1	1	1	1	7	1	1	1	1	1
Worn Excessively	3	3	1	1	1	1	7	1	1	1	1	1
E. Corrosion	12	11	1	1	1	4	13	1	1	1	1	1
Deposits	1	1	1	1	1	1	5	1	1	1	1	1
Leaking	1	1	1	1	1	1	5	1	1	1	1	1
Rust or Corrosion	10	9	1	1	1	1	13	1	1	1	1	1
F. Other	4	4	1	1	1	1	7	1	1	1	1	1
Manufacturing defect	4	4	1	1	1	1	7	1	1	1	1	1
II. EXTERNAL CAUSES	585	381	3	12	38	88	240	135	125	6	1	1
A. Foreign Object Damage	442	277	2	11	35	57	172	102	102	3	1	1
Battle damage (combat damage)	26	0	1	1	1	1	3	1	1	1	1	1
Bent	3	1	1	1	1	1	6	1	1	1	1	1
Broken	4	4	1	1	1	1	11	1	1	1	1	1
Buckled	4	0	1	1	1	1	7	1	1	1	1	1

TABLE G-III (Cont'd)

Blades from Aircraft Model(s): UH-1D H	REASON FOR REMOVAL	REASON FOR STRAPAGE									
		PART CAUSES					INTERNAL CAUSES				
		1. Part causes	2. Imbalance	3. Deterioration	4. Bonding failure	5. Corrosion	6. Error construction	7. Internal stress	8. Foreign object damage	9. Overstressing	10. Fatigue
II. EXTERNAL CAUSES	A. Foreign Object Damage (Cont'd)										
	Collapsed	2	109	1							
	Damaged part, chip, nick, etc.	122	111	1							
	Dented	135	39	1							
	Foreign object damage	55	12	1							
	Holes punched	39	0								
	Mutilated	1									
	B. Overstressed	126	91	3							
	Crash damage	2	0								
	Hard Landing	1	1								
	Hit tree	1	0								
	Jammed	12	9								
	Overstressed	1	1								
	Overtorque	75	60								
	RPM out of limit	31	20								
III. NO FAILURE CAUSES	Sudden stoppage	2	0								
	Warped	2	2								
	C. Heat Damage	2	2								
	Heat damage	15	11								
	D. Maintenance & Shipping Damage	12	22								
	Bad patch, rivet, mod. tab, etc.	1	0								
	Damaged in shipment	2	0								
	Improper handling	0	0								
	E. Other	25	21								
	A. Time Change	2	1								
	Allowable operating time	23	20								
	B. Other										
	Inspect, evaluate, or repair										

TABLE G-III (Cont'd)

Blades from Aircraft Models: UH-1D H		REASON FOR REMOVAL										
REASON FOR REMOVAL		REASON FOR REMOVAL										
		ALL CAUSES	1. PART CAUSES	A. Imbalance	B. Perforation	C. Rooting failure	D. Corrosion	E. Material failure	F. Foreign objects	G. Fatigue	H. Other	I. Total
III. NO FAILURE CAUSES		16	3	1	1	1	1	1	1	1	1	1
3. Other (Cont'd)		16	3	1	1	1	1	1	1	1	1	1
Lost or missing bolt		4	1	1	1	1	1	1	1	1	1	1
No failure		4	1	1	1	1	1	1	1	1	1	1
Scheduled maintenance		4	1	1	1	1	1	1	1	1	1	1
IV. UNKNOWN CAUSES		16	3	1	1	1	1	1	1	1	1	1

TABLE G-IV. REASON FOR REMOVAL VS. REASON FOR SCRAPPAGE OF C/G MAIN ROTOR BLADES PROCESSED BY BHC

Blades from Aircraft Model(s): UM-1C/AH-1G

Part No.: 56-0000-00-05

REASON FOR REMOVAL

REASON FOR SCRAPPAGE										
I. PART CAUSES					II. EXTERNAL CAUSES					III. OTHER
A. Imbalance	B. Deterioration	C. Bonding Failure	D. Corrosion	E. Water Contamination	A. Foreign Object Damage	B. Overstressed	THE CHANGE			

ALL CAUSES	102	22	6	30	192	157	37	20	23
I. PART CAUSES									
A. Excessive Vibration Beyond specified tolerance	29	9	1	1	3	1	1	1	1
Can't balance	16	1	1	1	3	1	1	1	1
Erratic	17	1	1	1	3	1	1	1	1
Excessive vibration	1	1	1	1	3	1	1	1	1
B. Deterioration Cracked	4	5	1	1	3	1	1	1	1
C. Bonding Failure Bond separation	15	3	1	1	3	1	1	1	1
Delaminated	13	1	1	1	3	1	1	1	1
Loose	11	1	1	1	3	1	1	1	1
D. Excessive Wear	1	1	1	1	3	1	1	1	1
E. Corrosion Rust or corrosion	0	2	1	1	3	1	1	1	1
F. Other	4	2	1	1	3	1	1	1	1
II. EXTERNAL CAUSES									
A. Foreign Object Damage Battle damage (combat damage)	188	39	4	13	139	120	10	0	0
Bent	170	32	4	13	132	113	9	0	0
Damaged part. chip, nick, etc.	3	1	1	1	3	3	1	0	0
Dented	48	12	1	3	35	31	1	0	0
Foreign object damage	19	4	1	3	27	23	1	0	0
Holes punched	12	3	1	3	20	17	1	0	0
Mutilated	17	0	1	3	21	18	1	0	0
B. Overstressed	1	2	1	2	7	6	1	0	0
Crash damage	17	7	1	2	27	23	1	0	0
Hard landing	2	0	1	2	5	4	1	0	0
Hit tree	4	0	1	2	7	6	1	0	0
Overstressed	3	0	1	2	6	5	1	0	0
RPM out of limit	3	0	1	2	6	5	1	0	0
Sudden stoppage	1	1	1	2	5	4	1	0	0

TABLE G-IV (Cont'd)

Blades from Aircraft Model(s): UH-1C/AH-1C		Part No.: 544-01-00-2													
REASON FOR REMOVAL		REASON FOR SCRAPAGE													
		I. PART CAUSES							II. EXTERNAL CAUSES						
		A. Imbalance	B. Deterioration	C. Bonding failure	D. Corrosion	E. Water contamination			A. Foreign object Damage	B. Overstressed	III. THE CRASH	IV. OTHER			
II. EXTERNAL CAUSES	C. Heat Damage	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D. Maintenance and Shipping	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	E. Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0
III. NO FAILURE CAUSES	A. Time Change	21	18	18	18	18	18	18	18	18	18	18	18	18	18
	B. Allowable operating time	18	18	18	18	18	18	18	18	18	18	18	18	18	18
	Other	2	2	2	2	2	2	2	2	2	2	2	2	2	2
IV. UNKNOWN CAUSES	No failure Scheduled maintenance	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		79	79	79	79	79	79	79	79	79	79	79	79	79	79

APPENDIX H

DETAILS OF THE PROBABILITY OF SCRAPPAGE AND REPAIR ANALYSES OF MAIN ROTOR BLADES REMOVED IN VIETNAM

TABLE H-1. REASONS FOR REMOVAL VERSUS NUMBER OF D/H MAIN ROTOR
BLADES REMOVED, SCRAPPED, SHIPPED AND REPAIRED

Blades From Aircraft Models (a): UH-1D H		Reason for Removal										Repair Facility				Red River				Removal Organization				Total			
Reason for Removal		Total										Repair Facility				Red River				Removal Organization				Total			
CONTAINED CAUSES		Repair										Repair				Repair				Repair				Repair			
1. REMOVAL CAUSES		14										14				14				14				14			
A. EXCESSIVE VIBRATION		20										20				20				20				20			
Beyond specified tolerance		4										4				4				4				4			
Excessive vibration		0										0				0				0				0			
Mismatched		0										0				0				0				0			
Cut of adjustment		0										0				0				0				0			
Unable to adjust limits		0										0				0				0				0			
Unbalanced		0										0				0				0				0			
Unstable		0										0				0				0				0			
B. DEREGISTRATION		2										2				2				2				2			
Bent		2										2				2				2				2			
Cracked		0										0				0				0				0			
Deteriorated		0										0				0				0				0			
C. BONDING FAILURE		2										2				2				2				2			
Delaminated		2										2				2				2				2			
Loose		0										0				0				0				0			
Poor bonding		0										0				0				0				0			
D. EXCESSIVE WEAR		6										6				6				6				6			
Pitted		6										6				6				6				6			
Worn excessively		0										0				0				0				0			
E. CORROSION		5										5				5				5				5			
Corroded		5										5				5				5				5			
Leaking		0										0				0				0				0			
2. EXTERNAL CAUSES		25										25				25				25				25			
A. FOREIGN OBJECT DAMAGE		20										20				20				20				20			
Battle damage		20										20				20				20				20			
Bent		0										0				0				0				0			
Broken		0										0				0				0				0			
Cracked		0										0				0				0				0			
Cut		0										0				0				0				0			
Dented		0										0				0				0				0			
Foreign object damage		0										0				0				0				0			
Vicked		0										0				0				0				0			
Partially		0										0				0				0				0			
Total		10										10				10				10				10			

* Part and External Causes Only

TABLE H-I (Cont'd)

Blades From Aircraft Model(s): UH-1D, H

Reason for Removal	Total Removed	Removal Organization		Red Water		Blade Location		Remarks	
		Repair	Scrap	Ship	Head	Hub	FWC	Per. Air	Per. Air
11. EXTERNAL CAUSES (Cont'd)									
B. Overstressed	22	0	3	12	0	0	0	0	0
Crash damage	4	0	0	0	0	0	0	0	0
Overstressed	14	0	2	9	0	0	0	0	0
Sudden stoppage	8	0	0	3	0	0	0	0	0

TABLE H-II. REASONS FOR REMOVAL VERSUS NUMBER OF C/G MAIN ROTOR
BLADES REMOVED, SCRAPPED, SHIPPED AND REPAIRED

Blades From Aircraft Model(s): UH-1C/AH-1G Part No.: 560-000-001-1

Reason for removal	Total Removed	Removing Organization		Red River		Repair Facility		Total		% Retained
		Repair	Scrap	Held	Scrap	Repair	Scrap	Repair	Scrap	
COMBINED CAUSES*	336	54	182	100	63	3	23	2	3	25
I. PART CAUSES	44	7	23	14	6	1	3	2	33	25
A. Excessive Vibration	11	3	5	3	0	0	0	0	0	0
Beyond specified tolerance	1	0	1	0	0	0	0	0	0	0
Excessive vibration	1	0	0	0	0	0	0	0	0	0
Improper alignment	1	0	0	0	0	0	0	0	0	0
Improper tracking	1	0	0	0	0	0	0	0	0	0
Mismatched	1	0	0	0	0	0	0	0	0	0
Unable to adjust limits	1	0	0	0	0	0	0	0	0	0
Unbalanced	1	0	0	0	0	0	0	0	0	0
B. Deterioration	18	0	13	3	4	0	0	0	0	0
Cracked	17	0	13	3	4	0	0	0	0	0
Deteriorated	1	0	0	0	0	0	0	0	0	0
C. Bonding Failure	7	1	4	2	0	0	0	0	0	0
Delaminated	6	0	4	2	0	0	0	0	0	0
Poor bonding	1	1	0	0	0	0	0	0	0	0
D. Excessive Wear	7	3	0	4	3	0	0	0	0	0
Worn excessively	7	3	0	4	3	0	0	0	0	0
E. Corrosion	1	0	1	0	0	0	0	0	0	0
Corroded	1	0	1	0	0	0	0	0	0	0
II. EXTERNAL CAUSES	292	47	159	86	55	2	20	1	24	25
A. Foreign Object Damage	270	43	147	80	55	2	20	1	24	25
Battle damage	75	9	51	15	14	0	5	0	5	0
Bent	6	0	0	1	0	0	0	0	0	0
Broken	2	0	0	1	0	0	0	0	0	0
Chipped	5	0	0	1	0	0	0	0	0	0
Cut	30	1	3	1	7	0	0	0	0	0
Dented	76	17	43	13	12	0	0	0	0	0
Foreign object damage	1	0	1	0	0	0	0	0	0	0
Nicked	74	13	35	26	23	0	0	0	0	0
Punctured	1	1	0	0	0	0	0	0	0	0
Torn	1	1	0	0	0	0	0	0	0	0

* Part and External Causes Only

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13. ABSTRACT <p>This report presents the results of an investigation of the impact of the Army's operational environment on UH-1 and AH-1 series main rotor blades. Thirty-nine months of operational data for missions flown in the United States as well as in Southeast Asia under actual combat conditions were reviewed and reported. Blade failures are reported in terms of cause, frequency, repairability, and probability of blade scrappage following removal. The maintenance man-hours associated with each type of repair, the most forward area at which repairs may be accomplished, and the associated downtimes and support costs are reported. Repair, overhaul, and new blade costs are converted to operational costs in dollars per flight hour. The concepts of blades with a high degree of field repairability and "throwaway" blades are discussed. Tagret new blade costs at which such concepts become cost effective are developed.</p>			

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10. KEY WORDS	LINK A		LINK B		LINK C	
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Rotor Blade Design UH-1 Series Helicopters Operational Environment - Impact on Life Cycle Costs Rotor Blade Maintenance						

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